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BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Logistics Planning For The M 1 Tank: Implications For Reduced Readiness And Increased Support Costs

Achieving established design-to-cost objectives and fielding a tank within a 7-year development cycle have been the major emphases of the M1 tank program. As a consequence of this momentum, there was little early emphasis on logistical support and life-cycle cost issues. While the Department of Defense recognizes the need to emphasize and more thoroughly evaluate the M1's supportability, GAO is concerned that current testing may not provide the information for DOD's planned September 1981 decisions on M1 full production and fielding.

While the supportability issues need to be resolved, there are also opportunities for DOD to reduce the M1's life-cycle ownership and support costs. These objectives could be achieved by supporting the M1 reliability and maintainability improvement programs, implementing alternative strategies for procuring spare and repair parts, and reevaluating the number of tanks planned for training.

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UNITED STATES GENERAL ACCOUNTING OFFICE

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To the President of the Senate and the
Speaker of the House of Representatives

This report identifies deficiencies in the Army's ability to provide support capability for the M1 tank, raises questions about the tank's readiness for full production and fielding, and recommends alternatives for reducing future M1 support costs. We initiated this review in response to growing congressional concern that, while support costs for weapon systems have been drastically increasing, recently fielded systems are not achieving required operational readiness. Additionally, we addressed congressional concern previously raised over the M1's degree of design maturity and readiness for full production and fielding.

The report discusses how more effective front-end logistics planning would have produced a more affordable and supportable tank system. It questions current M1 program milestones.

Copies of this report are being sent to the Director, Office of Management and Budget; the Secretary of Defense; and the Secretary of the Army.

Milton J. Socolar
Acting Comptroller General
of the United States

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

LOGISTICS PLANNING FOR THE M1 TANK: IMPLICATIONS FOR REDUCED READINESS AND INCREASED SUPPORT COSTS

D I G E S T

The M1 tank, the Army's new main battle tank, was designed by the Chrysler Defense Division and is being produced in the Army's Tank Plant in Lima, Ohio. On the basis of the Army's projection of a 7,058-M1 fleet, acquisition costs are currently estimated at $19 billion--$2.5 million for each tank. This figure includes research and development and production costs, but does not include the anticipated costs of operating and supporting the M1 over its 20-year projected life cycle.

Integrated logistics support planning--the approach to weapons system development which attempts to link development and production to deployment and operation--has not been adequate or timely for the M1 tank program. Although recent planning efforts have improved, many supportability questions remain. Also, opportunities exist to reduce M1 support costs.

M1 program emphasis, as supported by the Congress, has been on achieving established design-to-cost objectives and fielding a tank within a 7-year development cycle. As a consequence of this program momentum, there was little early emphasis on logistical support and life-cycle cost issues. For example:

--It was decided not to fund integrated logistics support development during prototype competition between Chrysler and General Motors. Instead, it was planned that low-rate initial production would provide sufficient time for supportability to mature before large quantities of tanks were fielded.

--While the Army believes the M1 has been the most tested combat vehicle in its history, prototypes have not been available when needed for designing and testing logistical support.

--Program requirements and testing have been directed at inherent tank design performance, and the development of logistics supportability lags far behind the tank's development.

PLRD-81-33

The Department of Defense (DOD) and the Army recognize the need to more thoroughly evaluate M1 operational support characteristics and improve supportability. For example, the Army has proposed over $200 million for design improvements in reliability, availability, maintainability, and durability, but the Army's proposal has not been fully funded.

ONGOING M1 TESTING MAY NOT PROVIDE INFORMATION NEEDED FOR SOUND DECISIONS OF FULL PRODUCTION AND FIELDING

Supportability questions, still to be answered, include

--Can the M1 tank be operated and supported in a realistic operational environment at acceptable levels of operational readiness?

--Have reliability, availability, maintainability, and durability requirements been achieved or are they achievable?

--What will be the operation and maintenance costs associated with the M1--considering currently demonstrated levels of reliability?

--Have sufficient quantities of required logistics support resources been identified and acquired?

--Has the M1 maintenance concept been fully evaluated and has the required number of personnel been identified and trained?

DOD's ongoing operational and developmental M1 testing (scheduled for completion in May 1981 and January 1982, respectively) is supposed to provide the data needed to answer such questions on operational supportability. However, GAO believes that emerging results from current testing raise serious doubts that the M1 will be proven supportable before full production and fielding decisions are made in September 1981. GAO is concerned that the past momentum of the M1 program will push the program forward, even though many supportability issues remain.

DOD believes the M1 is supportable in the near-term, considering the relatively low-production rate and intensive management of logistics issues. DOD also believes that current testing will provide adequate supportability information

on which to base a sound full production and fielding decision at the scheduled System Acquisition Review Council meeting in September 1981.

GAO believes that improvements can be made in evaluating test data to better measure supportability and provide better data on which to base upcoming production and fielding decisions. Also, because of past congressional concern regarding M1 supportability and the potential that insufficient data will be available to support the upcoming M1 program decisions, the Congress should be provided the information DOD uses for these decisions. (See p. 38.)

M1 SUPPORT COSTS CAN BE REDUCED

While there are still supportability issues to resolve, DOD has opportunities to reduce M1 life-cycle ownership and support costs, which are projected in the billions of dollars. The following are possible opportunities.

--Since the Army considered acquisition costs, as opposed to total ownership costs, in developing the M1, the contractor was encouraged to select systems, components, and parts based upon initial procurement costs. The contractor rejected components that would initially be more expensive but which would be cheaper over the tank's life because of improved reliability or maintainability. (See p. 18.)

--In support of proposed M1 fielding requirements for the first 2 years, the Army has spent over $400 million to procure spare and repair parts. Delays in tank deployment and reductions in initial tank productions will reduce initial spare and repair parts requirements and continued modification of various tank systems may make many parts obsolete before they are needed. (See p. 61.)

--Army plans to buy 348 M1 training tanks, costing over $887 million, appear excessive given the low use of M60 training tanks and also the planned expenditure of $250 million to acquire M1 training devices. The reduction of tanks at training activities could allow earlier distribution of tanks to operational units. (See p. 70.)

RECOMMENDATIONS

Because of the need to demonstrate the M1's supportability, GAO recommends that the Secretary of Defense direct the Secretary of the Army to:

--Establish additional criteria, at the system and subsystem levels, for evaluating tests that place greater emphasis on operational effectiveness measures and assessments of future support costs. This criteria should include goals and thresholds for logistics burden and operational availability. (See p. 38.)

--Quantify and evaluate the potential impact (in terms of increased support and retrofit costs, reduced operational readiness capability, etc.) of producing and fielding the M1 with currently demonstrated levels of reliability, availability, maintainability, and durability. (See p. 38.)

--Reevaluate current M1 program plans for increasing production capacity, monthly tank production goals, deployment to Europe, and acquisition of long lead production items and spare parts, considering the current level of design maturity of the tank and its support system, tank production and quality control problems, and other factors. (See p. 38.)

--Increase support for the development, acquisition, and evaluation of required logistics support capability (for example, maintenance capability, test equipment, and technical manuals). (See pp. 47 and 59.)

GAO also recommends that the Secretary of Defense provide key congressional committees with information on the M1's logistics burden and quantify (in terms of increased maintenance costs and reduced operational readiness) the impact of fielding the M1 system at its current level of maturity or delaying the program. (See p. 38.)

To reduce potential life-cycle costs of the M1, GAO recommends that the Secretary of Defense:

--Increase support for M1 reliability and maintainability improvement programs, recognizing the potential to increase operational readiness and decrease future operational support costs through implementation of an effective life-cycle cost reduction program. (See p. 23.)

--Direct the Secretary of the Army to implement alternative procurement strategies to ensure that future spare and repair parts are procured using the most cost-effective methods consistent with the level of maturity of the tank and required technical data. (See p. 69.)

--Direct the Secretary of the Army to reevaluate the number of training tanks used in the M60 program and projected for the M1 program and to reallocate unneeded M60s and reduce the projected purchase of M1s or reallocate them to operational needs. (See p. 76.)

Other specific recommendations appear on pages 23, 47, 59, 68, and 76.

AGENCY COMMENTS

DOD concurs with GAO's major recommendations. (See app. IV.) DOD said that numerous steps are being taken to resolve or minimize the impact of the problems discussed. According to DOD, adequate supportability testing information, as well as results of actions described in response to the GAO report, should be available as a sound basis for a full production and fielding decision in September 1981. In this decision process, DOD says appropriate weighting will be given to all elements of the M1 system's performance.

The Army says it is committed to proceeding with M1 production buildup and deployment plans while recognizing the near-term potential for supportability problems. The Army anticipates some problems and is developing ways to minimize them until the problems are successfully resolved.

GAO's analysis of DOD and Army comments are included in each report chapter.

Contents

ABBREVIATIONS

ARRCOM	Armament Materiel Readiness Command
DARCOM	Materiel Development and Readiness Command
DOD	Department of Defense
GAO	General Accounting Office
ILS	integrated logistics support
LSA	logistics support analysis
OSUT-COFT	One station unit training - conduct of fire trainer
RAM-D	reliability, availability, maintainability, and durability
TACOM	Tank Automotive Command
TRADOC	Training and Doctrine Command
U-COFT	unit-conduct of fire trainer

CHAPTER 1

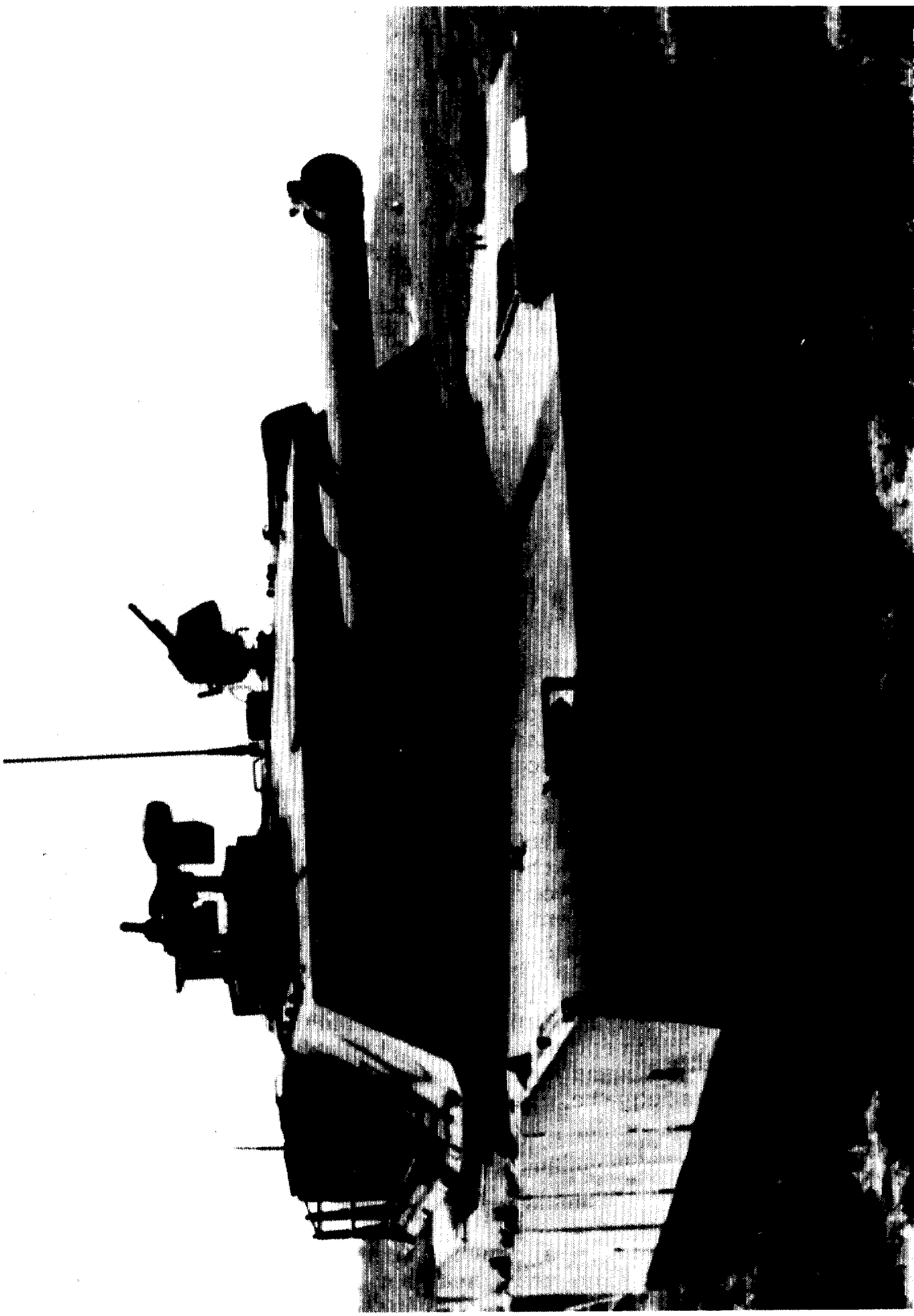
INTRODUCTION

To ensure that the Armed Forces can achieve the highest level of combat effectiveness, the Department of Defense (DOD) must continually review its weapon systems and their capabilities. When necessary, new systems are developed to provide improved capabilities over those currently in the DOD inventory.

Considered to be the Army's top priority weapon system, the M1 tank (see photograph on p. 2) was developed with the objective of providing significant improvement in combat capabilities over the present M60 series of main battle tanks. According to the Army, crew survivability--the highest M1 priority--is significantly improved through the incorporation of special armor and through compartmentalization of fuel and ammunition. An automatic fire detection and suppression system, a lower silhouette than the M60's, and high speed and agility also add to the tank's survivability potential. The 1,500 horsepower engine, the advanced torsion bar suspension, and the stabilization system are expected to provide a highly accurate capability for shooting on the move, a capability available only to a limited degree in some existing tanks. Initially, the M1 will be armed with a 105-millimeter main gun; however, the Army plans to incorporate a more lethal 120-millimeter gun in August 1984.

The elements of a system, such as the M1, include the prime mission equipment and its associated logistics support, such as support and test equipment, spare and repair parts, and personnel. The past is replete with instances where prime equipment is designed and the logistics support requirements evolve after the design is fixed. Frequently, the prime equipment design turns out to be lacking supportability, with the various elements of logistics support not compatible with the prime equipment or with each other. In such cases, the Government has paid the price through decreased levels of operational readiness and increased costs to support the equipment. We have frequently reported on these problems in the past. 1/ Our findings support the fact that many of the problems can be traced to DOD's acquisition process, particularly the early phases before system design is set. The pressure to attain specific performance goals, such as speed, range, and firepower, within tight time and cost constraints has often led management to make trade-offs or to otherwise not give adequate attention to long-term ownership considerations.

1/For additional discussion and a detailed list of previously issued reports addressing this subject, see our report "Effectiveness of U.S. Forces Can Be Increased Through Improved Weapon System Design" (PSAD-81-17, Jan. 29, 1981).



COURTESY OF U.S. ARMY

MI TANK

The Army Materiel Development and Readiness Command (DARCOM) has primary responsibility for the development and acquisition of the M1. The M1 Project Manager is the DARCOM authority for management of the program. Development and acquisition, in accordance with prescribed cost, schedule, and technical performance, and development of a full logistics support capability are the Program Manager's responsibilities. The Army Training and Doctrine Command (TRADOC) has represented the "user" community during the M1's development. The TRADOC System Manager is the focal point for all user program actions. In addition to the DARCOM Project Manager and the TRADOC System Manager, over 35 Army organizations have contributed to the M1's development and acquisition. The M1 is being produced by the Chrysler Defense Division in the Army Lima Tank Plant in Lima, Ohio.

On the basis of the Army's projection of a 7,058-M1 tank fleet, program acquisition costs were estimated at $18,955 million in December 1980. These costs include research, development, test and evaluation; procurement; training equipment; initial spares; and industrial plant equipment. They do not include operating and support costs. The per tank acquisition cost is $2,549,000.

THE LIFE CYCLE OF A WEAPON SYSTEM

The life cycle of a major weapon system commences with the program's initiation and extends through development, production, deployment, and operation to the system's eventual retirement from the inventory. Identifying the need for a weapon system, developing requirements, procuring the hardware and its support equipment, and testing and evaluating the system and its logistics elements are just a few of the complex functions which must be done during the four basic phases of the acquisition process. The four phases in increasing order of resource commitment are

--conceptual;

--demonstration and validation;

--full-scale engineering development; and

--production, deployment, and operational use.

Before proceeding from one phase to another, key Army and DOD officials must make reviews and decisions. To provide information for such decisionmaking, DOD requires that a comprehensive testing and evaluation program be instituted for each major weapon system. Testing and evaluation are necessary to assess acquisition risks and to evaluate operational effectiveness, suitability, and logistics support.

One of the most complex tasks in the weapon system acquisition process is the development of logistics support capability to ensure the effective and economical support of the system

throughout its programed life. Integrated logistics support (ILS) planning is required to achieve this objective. ILS planning must be an integral part of all aspects of a system's life cycle.

OVERVIEW OF THE M1 PROGRAM

The M1 was the Army's third attempt to design a new main battle tank. The first two programs--the MBT70 and the XM803--were considered unnecessarily sophisticated, excessively complex, and too expensive. Begun in 1963 as a joint development by the United States and the Federal Republic of Germany, the MBT70 program was terminated in 1970. After the Congress canceled the XM803 main battle tank program in 1971, the Army moved quickly to get its new tank program underway. The conceptual phase was accelerated by establishing a tank task force to formulate the new program. The results of the task force effort were published in August 1972. After further review to eliminate unnecessary features and to reduce costs, the M1 program was approved by the Deputy Secretary of Defense and was approved and funded by the Congress in 1973.

The goals of the 34-month validation phase (1973-1976) were to convert paper concepts into hardware, conduct production capability and cost studies, and select a design for entrance into full-scale engineering development. To achieve the benefits of competition as they relate to cost and design, the Army initiated a competitive prototype approach by awarding design and development contracts to Chrysler and General Motors Corporations. The management approach employed placed total system responsibility in the hands of the contractors. The contractors were given specified performance bands and cost parameters as the only constraints. To stay within specified unit hardware cost ceilings, the contractors were encouraged to make trade-offs within the performance bands. To assist in this, they were provided with an order of priority for the requirements.

On January 31, 1976, the Army received the prototype vehicles from the contractors and began evaluating the vehicles at Aberdeen Proving Ground, Maryland. This evaluation was completed on May 7, 1976. Test results showed that both candidate systems satisfied the Army's requirements and that the systems were ready to enter the next phase of development. Concurrently, with the delivery of the prototype vehicles, a Source Selection Evaluation Board was convened to evaluate the results of testing, review output from various analytical models, and probe the contractors' proposals.

During July 1976 Addendum 1 to an existing 1974 Memorandum of Understanding between the Federal Republic of Germany and the United States was negotiated. In this addendum, the United States and the Federal Republic of Germany agreed on areas of standardization for their respective tank systems. To ensure maximum standardization with the Federal Republic of Germany, the United States postponed selecting a single U.S. contractor

so that the standardized items could be incorporated into the contractors' proposals for full-scale engineering development. In September 1976 the Source Selection Evaluation Board was convened again to evaluate the Chrysler and General Motors proposals. During the second week in November, the Secretary of the Army was briefed on the Board's findings, and on November 12, 1976, he announced the selection of Chrysler Corporation as the prime contractor for the full-scale engineering development phase of the M1 program.

Succeeding phases of the M1 development and acquisition are discussed in more detail in later chapters of this report. Key program milestones are highlighted in the following chart. 1/

Full-scale engineering development	1976-79
Developmental and operational testing of 11 Chrysler prototype vehicles	March 1978- September 1979
DOD decision to proceed to production phase of program	April 1979
Low rate, initial production deliveries start	February 1980
Developmental and operational testing of production vehicles	March 1980 - January 1982
First M1 unit equipped (in United States for testing)	January 1981
Army decision to type classify the M1 standard	February 1981
Certification of tank availability for release for issue to U.S. Army in Europe	September 1981
DOD decision for full production and fielding	September 1981
Award full production contract	September 1981

1/M1 program milestones have been revised and redefined at various phases in the program. The dates provided were current as of April 1, 1981.

OBJECTIVES, SCOPE, AND METHODOLOGY

Since fiscal year 1979, we have issued three reports which address developmental and testing aspects of the M1 program. 1/ We initiated this review because of broad congressional concern that, although support costs for weapon systems have been drastically increasing, recently fielded systems are not achieving required operational readiness goals. Our intent was to assess the adequacy and effectiveness of ILS planning and the development of logistics supportability and to identify alternatives for achieving readiness objectives at reduced support costs.

We examined M1 ILS planning and strategies to (1) identify options for improving the M1 ILS program, (2) determine whether the implementation of current planning strategies will provide adequate logistics support, and (3) evaluate alternative logistics strategies which could more economically provide effective logistics support. We reviewed historical documentation to determine if ILS considerations received proper emphasis in earlier program phases, and we analyzed earlier test and evaluation reports to identify the deficiencies found. We also evaluated the Army's efforts to correct these deficiencies and assessed the current status of ILS development based on early reports from ongoing developmental and operational testing.

The overall criteria on which we based our review included various DOD and Army policies, regulations, and directives on the weapon system acquisition process, ILS, and logistics management practices and procedures. Specific references to these criteria are identified as appropriate in subsequent report chapters. Our approach was to first examine the overall ILS effort and then to examine each ILS functional element to evaluate its effectiveness and economy.

We made our review at the following activities, each of which has key responsibilities in the development, acquisition, production, or testing of the M1 tank or in the development and implementation of the M1 ILS system.

--Office of the Secretary of Defense
  Washington, D.C.

--Headquarters, Department of the Army
  Washington, D.C.

1/(1) "Major Deficiencies Disclosed in Testing of the Army's XM1 Tank Warrant Slower Production" (PSAD-79-67, Apr. 16, 1979), (2) "XM1 Tanks Reliability Is Still Uncertain" (PSAD-80-20, Jan. 29, 1980), and (3) "Matters Relating to the XM1 Tank" (Apr. 16, 1980).

--DARCOM
Alexandria, Va.

--TRADOC
Fort Monroe, Va.

--Office of the Project Manager, M1 Tank System
Warren, Mich.

--Army Armament Materiel Readiness Command
Rock Island, Ill.

--DARCOM Materiel Readiness Support Activity
Lexington, Ky.

--Army Operational Test and Evaluation Agency
Falls Church, Va.

--Army Test and Evaluation Command
Aberdeen Proving Ground, Md.

--Army Materiel Systems Analysis Activity
Aberdeen Proving Ground, Md.

--Army Ordnance Center and School
Aberdeen Proving Ground, Md.

--TRADOC System Manager, M1 Tank System
Fort Knox, Ky.

--Army Armor Center and School
Fort Knox, Ky.

--Army Logistics Center
Fort Lee, Va.

--Army Training Support Center
Fort Eustis, Va.

--Office of the Project Manager for Training Devices
Orlando, Fla.

--Chrysler Defense, Inc.
Sterling Heights, Mich.

--Army Lima Tank Plant
Lima, Ohio.

We were unable to evaluate all aspects of the M1 support environment. In addition to the areas discussed in this report, we are concerned about the availability of (1) vehicles to resupply fuel and ammunition, (2) adequate skill levels and numbers of troops to support M1 field activities, (3) Army reserve capability to

provide M1 support required during a mobilization. These concerns are described in more detail in appendix I.

This report also discusses some systemic problems with ILS planning and implementation in DOD, many of which have been previously identified in our earlier reports.

CHAPTER 2

IMPROVEMENTS NEEDED IN M1

ILS PLANNING

Recognizing that a weapon system and its elements of logistics support must be developed on an integrated basis to produce a cost-effective product, DOD directives and Army regulations require that an ILS plan be developed for each system and be made an integral part of the system's acquisition and operation.

In establishing objectives for the M1 tank program, the Army failed to adequately consider ILS planning. The development of logistics was not funded concurrently with the development of the tank. Logistics considerations have consistently been the lowest priority and have been exchanged in favor of other program considerations.

As a result, the development of M1 logistics support capability has not been adequate or timely to assure that (1) the M1 can be operated and supported in a realistic operational environment to achieve required levels of readiness, and (2) required logistics supportability can be achieved at an affordable cost.

While it is too late to achieve the primary benefits of effective front-end logistics support planning, opportunities still exist to improve this planning process and to develop a more cost-effective and more operationally supportable tank system.

WHAT IS ILS?

ILS planning, as set forth in DOD and Army guidance, is intended to be an overall approach to weapon system design, development, testing, and operation. It is also intended to strike an optimum balance among the total system performance, cost, and schedule while an integrated support system is developed. To be fully effective, ILS planning must be implemented in the earliest stages of the acquisition process and continually modified and updated, as appropriate, throughout the life cycle of a system. Guidance for ILS planning was first issued on June 19, 1964, as DOD Directive 4100.35 (Development of Integrated Logistics Support

for Systems and Equipment). 1/ In 1970 it was made a requirement for major acquisitions. However, the basic ILS objective remained the same--to provide the optimum level of support at the proper location and at the right time. The ILS function provides the initial planning, funding, and controls which help to ensure that the ultimate user will receive a system that will not only meet performance requirements, but one which also can be expeditiously and economically supported throughout its programed life cycle.

The ILS plan

ILS should be documented through the development of a plan--a master index and schedule of required support planning documents which are used to ensure that logistics support elements are developed and produced when required. The principal elements of an ILS plan are (1) maintenance, (2) personnel, (3) supply support (including initial provisioning), (4) support and test equipment, (5) training and training devices, (6) technical data, (7) computer resources, (8) packaging, handling, storage, and transportation, and (9) facilities.

Through effective ILS planning, the military services can

--allow logistics support considerations to influence requirements and design,

--define support requirements that are best related to the system's design and to each other,

--acquire the needed support, and

--provide the support during the operational phase at minimum cost.

1/DOD Directive 4100.35 was revised and reissued in January 1980 as DOD Directive 5000.39. DOD Directives 5000.1 (Major System Acquisitions) and 5000.2 (Major System Acquisition Procedures) were revised in March 1980 and provide additional stress on the importance of logistics support planning early in the acquisition process. Department of the Army guidance for ILS can be traced to November 1969 when Technical Manual 38-703 (ILS Management Guide) was published. Army Regulation 700-127 (April 1975) and other guidelines provide additional ILS criteria.

Logistics support analysis: the integrator in ILS

Logistics support analysis (LSA) is a management tool for implementing ILS. 1/ LSA is an iterative analytical process which identifies the logistics support necessary for a new weapon system. It provides for

--initial determination and establishment of logistics support criteria or constraints which affect the design,

--consideration of those criteria in the system design,

--provisioning of logistics support elements, and

--final analysis of the design to validate its feasibility in terms of total logistics support effectiveness.

Logistics support analysis is documented through the development of LSA records which should provide a single centralized data base to input, store, process, and retrieve logistics data. All tasks required to operate and maintain a weapon system should be entered on the records and analyzed to identify required logistics resources. 2/ Once established, these records should provide a useful management tool during successive phases of a weapon system program.

ILS PLANNING FOR THE M1

As with other weapon system programs initiated in the late 1960s and early 1970s, in planning the M1, the pressures to attain specific performance goals (such as survivability, speed, range, and fire power) within tight time and cost constraints led Army management to make trade-offs or to not give adequate attention to long-term ownership considerations. As a result, the Army's overall ILS objective--the fielding of an affordable materiel system that meets required levels of operational readiness and is fully supportable in an operational environment, within

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1/Guidance for implementing LSA is provided by Military Standard 1388 (Oct. 15, 1973) and various DOD directives and Army regulations. LSA evolved from an earlier process called maintenance engineering analysis, which more heavily concentrated on maintenance factors as opposed to the total impact of all logistics elements.

2/Logistics resources include maintenance staff hours, personnel and skills, allocation of maintenance tasks, repair parts, support and test equipment, operator and maintenance publications, facility requirements, reliability, availability, and maintainability.

Army resource constraints--will not be easily achieved for the M1.

Deficiencies in early M1 logistics planning

The Army did not fund the development of logistics support during the validation phase of the M1 program. Instead, the Army funded General Motors and Chrysler to develop concepts and to construct prototype vehicles for competitive evaluation, but logistics support was not a primary consideration. Army officials stated that to fund logistics development in a competitive program would result in duplication of unnecessary effort. However, we believe that because of the lack of emphasis on logistics in the M1 design contract, the Army missed opportunities to evaluate alternative support concepts, to make trade-offs between system design and logistics support elements, and to make trade-offs among integrated logistics support elements to meet system readiness objectives at minimum life-cycle costs. The following are examples of some of these lost opportunities.

--M1 program emphasis has been on holding down initial production cost without adequately considering life-cycle operating and support costs. Opportunities were missed to incorporate supportability considerations into the design of new systems and components. Design decisions and component selections were made which may greatly increase support costs for the M1. (See chs. 3 and 5.)

--Reliability, availability, maintainability, and durability (RAM-D) requirements established for the M1 only related to M1 hardware performance and did not adequately consider the constraints of the realistic operational environment in which the M1 must function. When operated in a normal field environment, the M1 may create a tremendous logistics burden--resulting in increased support costs and decreased operational readiness. (See ch. 4.)

Although ILS planning received greater emphasis during the M1's full-scale engineering development phase, logistics continued to receive low priority when compared to other program parameters. The M1 requirements document included a priority list of 11 characteristics. Since the lowest priority was logistics, contractors traded off logistics considerations and concentrated on operational and performance requirements.

During the full-scale engineering development phase, the Army contracted with Chrysler to perform LSA; however, only limited LSA data requirements were specified in the Army's engineering development contract. Furthermore, the LSA implementation came too late to have any significant influence on the development of logistics support resources, and the Army did not adequately review the LSA data generated by Chrysler. Only

limited data was processed, and it was of poor quality and not timely. (See chs. 5 and 7.)

Without having a documented LSA record to provide an integrated baseline for determining M1 support requirements, logistics support planners were forced to use other sources of information to identify and document logistics support requirements. Thus, LSA in the M1 program has ended up being little more than historical documentation rather than as an analysis/integrating tool to influence design and identify logistics support resource requirements.

The effect of this fragmented logistics support development can be illustrated by the fact that in 1980 (after the M1 program entered the production phase), officials from the Army Ordnance Center and School identified four different versions of M1 maintenance allocation procedures. Recognizing that the allocation of maintenance is the hub around which most integrated logistics support items should revolve, these officials raised concern over the lack of continuity in M1 maintenance planning. Increased program resources were dedicated to resolving differences of opinion regarding maintenance allocations, but Army officials told us in March 1981 that levels of maintenance are still changing for some M1 components. Furthermore, ongoing tests will not include procedures for evaluating the total M1 maintenance concept which is expected to be used in support of the M1 when fielded in Europe. (See ch. 4.)

Another impact of the fragmented development of logistics resources is found in the discongruity among various logistics support elements. For example, ongoing operational tests have demonstrated that test and diagnostic equipment and technical manuals are in many cases not compatible with each other nor with the M1 tank. In other instances, spare components and parts, special tools, and other items needed to perform maintenance are not available. Because of these deficiencies, maintenance technicians are often unable to isolate faults and to accomplish repairs in a timely manner. (See chs. 4, 5, 6, and 7.)

Current status of M1 logistics support development

The schedule of major M1 logistics support events on the following page demonstrates that the development of logistics support capability has lagged far behind schedule. The M1 logistics support plan stated that "all supportability issues will be verified prior to the start of low rate initial production." However, in commenting on a draft of this report, DOD said that it was planned that low rate initial production would provide sufficient time for ILS and supportability to mature before large quantities of tanks are fielded.

Status of M1 Logistics Support Development, April 1981

	Date scheduled to Begin	Date scheduled to End	Date completed	Date scheduled for completion
Conduct validation of technical manuals	Feb. 1977	Nov. 1980	Incomplete	Feb. 1981 to Nov. 1982
Conduct physical teardown and maintenance evaluation	Not originally scheduled		March to May 1978	
Conduct maintenance evaluation	Dec. 1976	Dec. 1979	Incomplete	1982
Submit technical documentation	June 1978	Nov. 1979	Incomplete. Baseline established as of Sept. 1979	Must be continually updated as the tank configuration changes
Verify support and test equipment capability	Mar. 1978	Sept. 1979	Incomplete	
Prepare depot maintenance support plan	June 1979	May 1980	Incomplete	
Develop and submit final requirements for maintenance staff hours	Dec. 1976	Nov. 1979	Incomplete	June 1981 or after completion of phase III tests
Prepare depot maintenance work requirements (note a)	June 1979	Nov. 1980	Incomplete	1982 to 1984
Perform pilot depot overhaul	Dec. 1980	Mar. 1981	Incomplete	Feb. 1983 to Dec. 1984
Develop full Government depot capability		Mar. 1981	Incomplete	Anniston Depot - 1983 Mainz Depot - 1986

	Date scheduled to Begin	End	Date completed	Date scheduled for completion
Conduct final verification of personnel requirements	June 1979	Nov. 1979	Incomplete	Final personnel requirements submitted but not approved
Field M1 training devices	May to Sept. 1980		Incomplete	July 1981 to 1986

a/Although the original M1 maintenance concept called for full organic depot maintenance capability before initial fielding in Europe, delays in depot support planning resulted in the necessity for contractor depot support of key M1 systems and components.

Increased emphasis on logistics considerations is needed for the M1E1 program

A major product improvement program, which involves replacing the existing 105-millimeter gun with a 120-millimeter gun, has been undertaken for the M1 program. This program--called the M1E1 --is a major redevelopment effort involving much more than a simple exchange of the cannon and ammunition. Considerable redesign is required in the tank's turret, including the fire control system, ammunition stowage area, gun mount and breech, gunshield, software modifications to the computer, repackaging of electronic rack components, and other changes. Because of the expected increase in the tank's weight, changes may also be required in the hull of the tank, including the transmission, track, suspension, and stabilization systems.

This redevelopment effort affords the Army the opportunity to reevaluate earlier program strategies and to revise the program structure and milestones, where appropriate, to accomplish the following:

--Increase emphasis on logistics.

--Ensure that front-end logistics planning for the program receives required emphasis and a sufficient balance of funding.

--Ensure that sufficient time is allowed for development and maturity of the equipment as well as logistics support resources, including training, personnel, supply support, maintenance, technical manuals, and test equipment.

CONCLUSIONS

As discussed in this chapter and in succeeding chapters, the impact of delaying logistics support planning until the full-scale engineering development phase, making logistics the lowest program priority, dedicating insufficient program resources to developing logistics support capability, and inadequately testing for logistics supportability has seriously affected the M1 program.

The Army is implementing corrective actions to resolve current gaps in the M1 system support package. While these actions demonstrate a vast improvement over earlier M1 ILS efforts, we believe that even greater emphasis and more concentrated management attention is needed to ensure that:

--Overall logistics planning is integrated.

--Sufficient program resources are dedicated to resolving deficiencies in the existing M1 ILS package.

--Cost, schedule, performance, and supportability considerations are properly balanced.

AGENCY COMMENTS AND OUR EVALUATION

In commenting on our draft report, DOD stated that it concurs in our major recommendations and that actions have been taken or initiated which address each of them. (See app. IV.)

DOD, however, did not comment on every recommendation and also stated that our report minimized many of the positive aspects of Army and M1 logistics support planning. For example, the M1 is the first major armored ground system with advanced technology test sets. The M1 also represents the first major implementation of the skill performance aids format for technical manuals with armored systems. According to DOD, M1 test sets and technical manuals will significantly contribute to a fully supportable M1.

We believe that with the high degree of sophisticated complexity and advanced technology represented by the M1, mature test sets and technical manuals are absolutely essential to its supportability. As discussed in subsequent chapters of this report, the maturity of M1 tests sets and technical manuals has lagged far behind tank hardware development. Deficiencies in the M1's total system support package have adversely affected the program. We believe, however, that recent Army actions have improved logistics support capability.

DOD further stated that we did not provide the total perspective on why the Army decided not to fund logistics development earlier in the program. We believe we have adequately recognized in our report that program objectives established by

the Army and supported by the Congress were to achieve established design-to-cost objectives and to field a tank within a 7-year development cycle. However, we do not believe that the intention of the Congress was to make trade-offs between supportability and life-cycle costs or to let scheduled milestones, as opposed to program accomplishment, be the pacing factor for the M1 program.

CHAPTER 3

LIFE-CYCLE COSTING: STILL TIME TO BENEFIT THE M1

Life-cycle costing is a procurement strategy that takes into account the total cost of product development, procurement, and ownership--recognizing that the purchase price of systems and equipment may be far less significant than subsequent ownership costs. The life-cycle costs of a system include all expenses for research and development, production, modification, transportation, introduction of the item into the inventory, new facilities, operation, support, maintenance, disposal, and any other ownership costs.

DOD initiated the life-cycle cost concept, and it was first used in the 1960s. Today, various directives and instructions 1/ have formalized life-cycle costing policy, and the Congress has considered and approved procurements based upon life cycle costing. 2/ The main motivation behind this strategy is the possibility of saving money on operation and support costs by spending somewhat more during research and development and initial procurement. A second motivation is to encourage long-range planning, especially for operation and support costs. This is especially important since the costs of operating and supporting a system, such as the M1, may be 70 to 90 percent of the system's life-cycle cost. Furthermore, since design and support decisions which are made during the conceptual and validation phases of the acquisition process may commit as much as 85 percent of future support costs, decisions made in the early stages of the acquisition process offer the greatest opportunity to positively influence system supportability and to decrease future support costs.

In developing the M1, the Army has not taken full advantage of the benefits achievable through effective life-cycle costing. The acquisition cost, as opposed to the total ownership cost, has been the dominant criterion on which M1 component and design selections were based. According to Army officials, a design-to-unit production cost goal was established for the M1 to combat previous tank development problems of excessive cost and complexity which resulted in the cancellation of earlier tank development efforts. The acquisition strategy adopted for the M1 was to

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1/Office of Management and Budget Circular A-109, Apr. 5, 1976; DOD Directive 5000.28, Aug. 1, 1976; DOD Joint Logistics Commanders' Guide to Design-to-Cost, Life Cycle Cost as a Design Parameter, 1977; DOD Directive 5000.1, March 19, 1980; DOD Directive 5000.39, Jan. 17, 1980.

2/U.S. Congress, House of Representatives, Department of Defense Appropriations Bill, 94th Congress, 1st session, October 1, 1975, 121 Cong. Rec. 31057-31088 (1975).

develop a tank system designed to achieve specified performance requirements, while not allowing initial unit production costs to exceed $507,790 (in 1972 dollars) for each tank. No incentives were established to encourage M1 contractors to identify potential reductions in life-cycle costs or to make system design decisions that took advantage of these savings.

Due to the current design maturity of the M1 program, only a small portion of the potential for savings remains. Although it is too late to take full advantage of the potential benefits from life-cycle costing, opportunities still exist for evaluating alternatives which could reduce future M1 support costs.

DIFFERENT WIRING HARNESSES COULD SAVE MILLIONS OF DOLLARS

Because of high acquisition costs, the Army and Chrysler have rejected a more advanced wiring harness for the M1, even though it offers safer operation and reduced life-cycle costs. However, there is still time to adopt this improved design and possibly save millions of dollars in future support costs.

High failure rates and severe maintainability problems have been a major problem with the wiring harnesses on Army tanks and other combat vehicles. The Army Armament Research and Development Command's May 1977 report on the M551 airborne assault vehicle cited numerous wiring harness problems, such as harness deterioration which permitted short circuiting and started fires. The report referred to the hostile environment (high heat, abrasion, and continued contact with diesel fuel) in which wiring harnesses are placed and concluded that wiring harness problems "not only present a tremendous cost in maintenance and replacement, but raise considerable doubt as to the reliability and safety of equipment." The report also stated that, without resolution of wiring harness problems, the M1 tank would experience similar failures.

The state of the art in wiring harnesses is the convoluted cable, a teflon tube protected with metal braiding through which electrical wires pass. Convoluted cabling has been used successfully for some time on the British Chieftan and other foreign-made armored vehicles. The British, who use convoluted cabling because of its high reliability and maintainability, claim they have kept no written history because failures occur infrequently.

Chrysler and Army officials said that convoluted cables were rejected for use on the M1 because of their high acquisition costs. Instead, heat shrinkable tubing which is made of either neoprene or a viton polymer blend (depending on its location in the tank) is being used to fabricate M1 wiring harnesses. Army officials stated that the material used for M1 wiring harnesses is an improvement over the material which is used in current armored vehicles. However, a 1979 Army Armament Materiel Readiness Command (ARRCOM) study concluded that neither neoprene nor viton

is as effective as the teflon-coated tubing. We found that M1 operational testing revealed similar problems to those experienced on older equipment, although limited duration of testing precluded complete evaluation.

A 1979 ARRCOM study of a selected M1 wiring harness concluded that by substituting the improved convoluted cable for the cable currently used on the total M1 tank fleet, the Army could save more than $18 million over 20 years. Because there is no documented reliability data for convoluted wiring harnesses in armor combat vehicles, the Army could not verify these savings, but the potential benefits are of such a magnitude that further evaluation should be initiated. While the ARRCOM cost study reviewed only 1 wiring harness, there are over 60 wiring harness cables in the M1. Each harness is subject to varying environmental conditions, usages, reliability factors, and maintainability considerations. Thus, an independent evaluation of the cost effectiveness of the convoluted cable would be needed for each type of M1 wiring harness. Since the convoluted cable represents current technology, we believe its adaptation for the M1 should be reconsidered because of the potential for large reductions in future operation and support costs.

According to Army officials, deficiencies in M1 wiring harnesses have been identified and a cable redesign has been recommended as a future product improvement. However, this project has not been funded. We were told that because of more pressing needs for other design improvements, an improved wiring harness design may never be implemented.

USE OF NONSTANDARD ITEMS MAY INCREASE M1 SUPPORT COSTS

In keeping with the Army's goal to hold down initial procurement costs, Chrysler is allowed to select nonstandard military items for the M1, even though an acceptable alternative may already be stocked in the military supply system. Although it may be initially cheaper to buy new items than to use those items already stocked, the introduction of new items into the supply system may result in increased life-cycle costs because of the need for cataloging, storage, inventory management, and increased maintenance requirements. Also, selecting new parts when an acceptable alternative is already stocked does not conform with current DOD emphasis on increased standardization.

For example, the same alternator used in the Army's M60A3 tank was originally selected for use on the M1. However, Chrysler later decided to use a different less expensive alternator not previously used by the Army. Although the procurement cost of the new alternator is lower, an M1 project office official stated that ownership costs will be higher. In addition to stocking the new alternator, the Army must stock other new items, including a wiring harness, a voltage regulator, and miscellaneous repair parts.

Army officials stated that while Chrysler had maximum design freedom in the selection of items of commercial origin or in the design of new items specifically for the M1 tank system, maximum use of standard military items was required. M1 program office officials believed that this contract requirement was followed and that any use of nonstandard military parts was done with the consideration of cost and design in conformity to the use of military standard parts.

We found that the Defense Logistics Agency had identified approximately 2,000 ARRCOM-managed items as having assigned national stock numbers, although Chrysler had specified a new part number for use on the M1 tank. According to M1 project office officials, where the standard military item has the same form, fit, and function as a previously identified tank part does, to preclude future duplicative stockage, Chrysler will identify the standard part number in the M1 technical data package. Thus, although the nonstandard part will be used on production tanks, the existing supply item may be used as appropriate during repair.

As long as Chrysler maintains configuration control of the M1, part number substitutions must be approved and technical data revisions must be processed by Chrysler. According to Army officials, supply items which Chrysler determines as unacceptable are not candidates for substitution.

CURRENT ARMY EFFORTS TO REDUCE M1 SUPPORT COSTS

Army officials stated that life-cycle cost considerations did figure prominently in several early decisions related to the design of the tank. For example, the turbine engine was selected because of its greater reliability and maintainability which is expected to result in considerable savings during the life of the tank. The Army agreed, however, that life-cycle costing was not the primary factor in the selection process for determining the design and selection of M1 components. It stated that when the Congress canceled the previous tank program (XM803), it was directed to design a tank that could be produced at about a third of the cost for the proposed XM803 design.

We recognize that congressional concern over the complexity, sophistication, and cost of previous tank designs influenced the Army's decision to concentrate on production costs. However, we believe that the Army, in trying to achieve maximum operational capability achievable within these overall program cost constraints, did not provide sufficient attention toward achieving the required balance among operational performance, RAM-D, and logistics supportability.

Recognizing that the future impact of logistics support costs has not received adequate consideration, the Army has begun to

identify areas where RAM-D improvements are needed and to establish programs to accomplish these improvements. The Army's M1 reliability and maintainability growth program was initiated in 1979. The objective of the program is to provide increased reliability for selected critical components and to improve designs that exhibit marginal RAM-D characteristics. Concurrent with the above effort is an integrated logistics support maturity program, whose objective is to continue to improve the quality of manuals and the adequacy of special tools and test sets and to reduce the spare parts required to support the tank. In addition, as a result of evaluating phase III developmental and operational testing, subsequent testing, and the manpower and logistics analysis, a maintainability improvement program will be established to reduce the tank's logistics burden.

Costs for the M1 reliability and maintainability growth programs, the maintainability burden program, and the ILS maturity program are about $206 million. DOD officials stated that correction of design deficiencies identified during ongoing testing may require additional funds. For example, as much as $50 million may be needed to increase the durability of the M1 tracks.

While we did not thoroughly analyze the merits of those items specifically addressed in the current logistics improvement programs, we believe that the programs' objectives are sound and deserve increased management attention. We also believe that these programs need to be implemented effectively if they are to help the M1 achieve required operational readiness at an affordable cost.

CONCLUSIONS

When effectively applied, life-cycle costing may be a key factor in enhancing the implementation of the ILS concept. The life-cycle cost estimating process provides management with an overall quantitative picture of an item's life-cycle and offers an opportunity to reduce future operating and support costs. Although the concept of life-cycle costing was initiated in the 1960's and various directives and instructions have formalized this costing policy, as demonstrated with the M1 and other weapon system acquisitions, life-cycle costing, as a procurement criterion, has not been effectively implemented in DOD.

By emphasizing initial unit production costs without adequately considering ownership costs, the Army has lost the opportunity to select available alternatives which could decrease the M1's future logistics burden and thus reduce life-cycle costs. Although it is too late to take full advantage of life-cycle costing benefits, the Army can still reexamine M1 design, component selection, and tank production in light of potential savings to be derived from using available alternatives.

We believe that the Army should reconsider using convoluted cables in M1 wiring harnesses. Additionally, where practical

and cost effective, the Army should use components and parts already stocked for those parts specified in the current M1 design. While we did not make an independent cost-benefit analyis, we believe the potential life-cycle cost savings are significant and further evaluation by the Army is needed.

Effective implementation of life-cycle costing involves the search for significant costs that can be influenced by planning and design decisions. We believe the Army has taken positive action toward identifying and analyzing M1 support costs through the manpower and logistics analysis. If properly implemented, this analysis should be a key factor in identifying needed M1 design improvements.

RECOMMENDATIONS

We recommend that the Secretary of Defense:

--Direct the various DOD components to implement effective life-cycle cost reduction programs.

--Support these life-cycle cost reduction programs during future program and budget reviews.

--Increase support for the M1 reliability and maintainability improvement programs, recognizing the potential to increase operational readiness and decrease future operational support costs through implementation of an effective life-cycle cost reduction program.

--Require the Secretary of the Army to implement M1 equipment design and logistics support alternatives, which could support readiness goals and reduce life-cycle costs. Evaluation of alternatives should include wiring harnesses, alternators, and other items discussed in this report.

AGENCY COMMENTS AND OUR EVALUATION

In commenting on our draft report, DOD agreed with our recommendation to provide funding for the M1 reliability and maintainability improvement programs. Funds programed by the Army for RAM-D growth are approximately $20 million for 1981, $10 million for 1982, and $6 million for 1983. For improvements in reliability, maintainability, and ILS, the Army has included $5.4 million in the 1982 budget request, $14.6 million in the 1981 supplemental request, and $31.1 million in the 1982 amended budget request. DOD also said that our recommendation concerning potential M1 life-cycle cost reductions would require increased funds in the fiscal years' 1982 and 1983 budgets to implement the reliability and maintainability growth program.

DOD challenged our draft report statement that actions can be taken to reduce M1 ownership costs by hundreds of millions of

dollars. As discussed in the body of this report, the ARRCOM wiring harness study we reviewed was not validated by the Army. However, we could find no documentation to refute the ARRCOM analysis. While "hundreds of millions" (based on one harness saving $18 million) may not be achievable because the convoluted cable would not be cost effective for all harnesses (each tank has over 60 cables), we still believe potential future ownership cost reductions are substantial and further evaluation of the convoluted cable is warranted.

DOD did not comment on our recommendations that the Secretary of Defense should direct DOD components to implement effective life cycle cost reduction programs and support these life-cycle cost reduction programs during future program and budget reviews. Since unit production cost, as opposed to life-cycle cost, is the primary factor in weapon system acquisition, there is need for further reenforcement of the criteria which at least in principal is contained in existing DOD directives and instructions.

CHAPTER 4

M1 SUPPORTABILITY MUST STILL BE DEMONSTRATED

Before deciding on a new weapons system's suitability for deployment and full production, DOD and the Army require that the system undergo rigorous developmental and operational testing. Testing and evaluation activities have historically concentrated their efforts on such operational considerations as survivability, fire power, range, mobility, and RAM-D. Although testing of the inherent supportability of a materiel system and of the adequacy of the planned support system has been a long-standing requirement, methodology describing how to test and evaluate logistics supportability has been slow to evolve.

As previously discussed in chapter 2, for the M1, like other system development efforts initiated in the early 1970s, supportability was not a major issue. RAM-D requirements specified in early program documentation were largely equipment oriented and failed to provide needed criteria for evaluating logistics supportability.

The Army has established some additional parameters for evaluating the M1's logistics supportability; however, goals and thresholds have not been established. Additionally, established criteria should be expanded to include other parameters, as specified in recent DOD reliability and maintainability directives.

Results from ongoing testing indicate that (1) not all RAM-D requirements will be met during ongoing testing, (2) continuing hardware failures will jeopardize the ability of the test to validate logistics supportability, (3) the logistics burden for the M1 will be much greater than the M60's, and (4) follow-on testing will be needed to validate design improvements, gather additional data for logistics evaluation, and identify and rank areas for future product improvement.

OVERVIEW OF MAJOR ACQUISITION TESTING REQUIREMENTS

Developmental testing, conducted by technicians, evaluates the system's equipment performance against design specifications. Operational testing is done by Army soldiers (both crews and mechanics) in a real world environment and evaluates how well the system performs and how well it can be maintained and supported. Normally, developmental testing precedes operational testing so that mechanical problems can be promptly corrected. Both developmental and operational tests consists of the following

three phases 1/, according to the weapon system's stage of development.

--Phase I assesses design prototypes for possible development and identifies early operational deficiencies.

--Phase II evaluates development prototypes to estimate military use, operational effectiveness, reliability, and logistics supportability in a real world environment.

--Phase III assesses the readiness of low-rate production systems for full production and fielding.

The Army also requires that Army mechanics make a physical teardown/maintenance evaluation to verify a system's logistics supportability for phase II testing. This evaluation should be made sufficiently in advance of phase II testing to allow for identification and correction of problems.

RAM-D AND LOGISTICS SUPPORTABILITY NOT ADEQUATELY DEMONSTRATED DURING EARLY M1 TESTING

RAM-D and logistics supportability of the M1 could not be fully verified during phases I and II testing because of the serious problems which were revealed in the tank's design, as well as in its functional logistics support capability (i.e., technical manuals, support and test equipment, trained personnel). Early phase III test results indicate that many problems continue to surface and it is doubtful that the M1 can achieve all RAM-D requirements specified in the various M1 program requirements documents.

Because of the constraints of a compressed development and testing schedule, the Army did not conduct phases I and II testing of the M1 as thoroughly as required. Maintainability and supportability testing was limited or deferred, and tests were not conducted in the prescribed sequence. As a result, problems identified in one stage of testing continued into successive stages. The momentum of the program and the recognition of the need for additional tank capability in the field pushed the M1's development forward into succeeding phases before testing was completed and test results were fully evaluated. Additionally, during earlier M1 testing, there was no requirement--as there is now--to evaluate operational supportability and projected support costs. Evaluation of quantifiable RAM-D characteristics, although based upon those requirements established in early M1 program

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1/Recent revisions to DOD directives and Army regulations now require only two phases of testing, but the third may be required if the system under development does not demonstrate required maturity.

documents, did not include effective measurements of realistic operational supportability.

What are RAM-D and logistics supportability?

Reliability, availability, and maintainability are measures of system supportability. Reliability is defined as the probability that a system will perform its intended function for a specified period of time under stated conditions. Reliability, which is usually stated as a meantime (distance, rounds, etc.) to failure, basically dictates the frequency of system/equipment maintenance. Durability is a special case of reliability which quantifies life expectancy. Maintainability concerns itself with the design for supportability, assuming items do fail or need preventive maintenance at some point in time. Maintainability, a measure of the ease with which an item may be maintained and repaired, is quantified as mean-time-to-repair. Availability is the probability that a system or equipment, when used under stated conditions, will operate satisfactorily when needed. Availability may be defined as equipment oriented--that is, to assume the equipment is operating in an ideal support environment. It may also be defined to describe a typical maintenance and supply environment.

Reliability and maintainability, as defined in most DOD and Army guidance, are inherent characteristics in the system or equipment design. As a result of recent DOD emphasis on ILS planning, logistics related goals must be established. For example, DOD Directive 5000.40 (Subject: Reliability and Maintainability, July 8, 1980) requires that reliability and maintainability criteria be related to operational effectiveness and ownership cost reduction, be measured by management, and be accounted for during the aquisition decision process. System reliability and maintainability must now be measured in four separate ways, using units of measurement directly related to (1) operational readiness, (2) mission success, (3) maintenance manpower cost, and (4) logistics support cost. Additionally, basic technical measures of reliability and maintainability should be defined in units capable of describing the system's reliability and maintenance parameters (i.e., maintainability should include all maintenance and repair times for attached and detached parts of the system).

Logistics supportability incorporates all characteristics of a system and its support elements as they contribute to the retention and restoration of the system in an operationally effective environment. RAM-D are sometimes considered quantifiable standards by which to measure supportability. However, in reality, logistics supportability is not readily quantifiable and can probably be most effectively addressed by evaluating how support concept, support material, and support personnel affect the system and are affected by the system.

M1 logistics requirements

A tabulation of M1 logistics related requirements, as specified in the January 1973 M1 material need statement, is shown in appendix II. In general, an evaluation of the M1's RAM-D and logistics supportability requirements will provide little information regarding the M1's total logistics burden. There is no requirement for availability--either inherent or operational. The M1's maintainability requirements only consider part of the total maintenance time, not all tank downtime. No assessment is made of required off-vehicle maintenance, and because of the M1's "pull and replace" modular design concept, off-vehicle maintenance is expected to be high.

While we recognize that measures of supportability effectiveness cannot be used to determine a contractor's compliance to meet required equipment related goals, we believe operational reliability and maintainability values should be tested and evaluated to estimate operational effectiveness and ownership cost and to determine where future reliability and maintainability improvement efforts should be concentrated.

Previous M1 RAM-D and logistics supportability evaluation was limited

DOD and Army guidelines for weapon system acquisition require that RAM-D and logistics supportability be demonstrated during phases I and II testing before production of new equipment begins. During phase I, an assessment of RAM-D was limited since, consistent with the M1 development plan, RAM-D achievement and assessment were scheduled for phase II. On the basis of the impact of the concurrency of M1 developmental and operational testing and the test, fix, and test mode under which the M1 test plan was conceived, a reliability growth program was established which provided that reliability would be evaluated not upon an achieved or demonstrated measurement, but upon a projection that required levels of reliability were achievable. This projection was based upon assumptions that design improvements to faulty equipment would alleviate pattern failures which occurred during testing. Unfortunately, the compressed M1 test program did not allow adequate time to retest all required tank modifications.

Army regulations provide that a physical teardown and maintenance evaluation should be a key function in the validation of logistics support capability for major systems. This event is intended to validate technical publications, special tools, test equipment, and the proposed maintenance concept. It should be made well before phase II testing begins to provide time to correct identified deficiencies.

A physical teardown and maintenance evaluation was not originally scheduled for the M1 program. Although an abbreviated maintenance evaluation was later made, it was accomplished concurrently with phase II testing. As a result, problems revealed in

the maintenance evaluation also occurred during phase II testing. The major logistics problems included the following:

--Numerous vehicle design deficiencies made proper evaluation of maintainability goals difficult.

--Test equipment did not function properly.

--Technical manuals were incomplete and inaccurate and did not reflect the same configuration as found on test vehicles.

--The proposed M1 maintenance concept could not be evaluated.

Because of the M1's compressed development schedule, the Army conducted developmental testing concurrently with--not before--operational testing. While certainly more expedient, this methodology has definite limitations, especially with regard to the evaluation of logistics supportability. It also complicates evaluation of RAM-D, since system redesign is occurring simultaneously with operational testing. Thus, it is difficult to assess RAM-D characteristics over the testing period. M1 phase II testing revealed critical deficiencies in the areas of engine, fuel and air systems, turret hydraulics, track, suspension, and the commander's weapon station.

Our previous report on the M1 1/ contains a detailed discussion of the M1's performance problems during phase II developmental and operational testing. Independent Army test evaluators, such as the Army Operational Test and Evaluation Agency and the Army Material Systems Analysis Activity, also reported serious problems in their evaluations of phase II testing. Additionally, the Logistics Evaluation Agency stated in its 1979 independent report of the M1 tank ILS program:

"Significant engineering development phase effort remains to be accomplished and demonstrated to allow logistics supportability to attain a status commensurate with the end item tank. Logistic elements such as TMDE [test, measurement, and diagnostic equipment], maintenance support concept, personnel, training, and TMs [technical manuals] trail end item tank development so much that extended engineering development will be required to catch up. End item tank status is such that extensive engineering development will be required to demonstrate mission reliability, maintenance burden, and power train durability thresholds. Projected successful fielding, approaching the goal of

1/"XM1 Tank's Reliability Is Still Uncertain" (PSAD-80-20, Jan. 29, 1980).

zero logistics support problems, on the current program schedule is not considered attainable."

The Logistics Evaluation Agency report recommended that the M1 program remain in full-scale engineering development and that the Army verify correction of deficiencies identified during phase II testing before making a production decision.

Despite these critical deficiencies, the Army and DOD review councils recommended that the M1 program proceed from the engineering development phase to the production phase. The Army System Acquisition Review Council type classified 1/ the M1 for limited procurement, and the Defense System Acquisition Review Council recommended low-rate M1 production in April 1979. In May 1979, the Secretary of Defense approved the production of 110 tanks and made further production contingent upon improved M1 performance in extended phase II testing.

At this time, the House Committee on Appropriations expressed concern about the M1 not demonstrating the required RAM-D capability during previous testing. The fiscal year 1980 Defense Appropriation Act restricted the use of M1 program funds until the Secretary of Defense certified that M1 RAM-D criteria specified in various program documents had been met.

Follow-on phase II testing was conducted between June and December 1979 to specifically address reliability and durability growth of the M1. Reliability of nonmobility subsystems (turret hydraulics) was not evaluated during this test. Furthermore, like phase I and earlier phase II testing, the extended testing could not establish the basis for evaluating maintainability and logistics supportability because of heavy contractor involvement (as opposed to Army troops) in these areas.

During the extended phase II testing, 1,007 incidents occurred which required maintenance actions. However, in scoring the test, most incidents were determined not to be chargeable against the tank's combat mission reliability. For example, 176 incidents were determined to be nonmobility in nature and were not scored against the system. The chart on the following page gives the reasons for excluding 763 incidents.

1/Type classification--an evaluation procedure for identifying the life-cycle status of a materiel system by the assignment of a designation which records the status of the system in relation to its overall life history as a guide to procurement authorization, logistical support, asset, and readiness reporting.

Description	Number of incidents
Engineering evaluation - no test	159
Item abuse	11
Error	54
Caused by another incident	35
Temporary fix for test	3
Detected at final inspection	2
Defer to scheduled maintenance	83
Crew fixed within 30 minutes	91
Fix leak by tightening	2
Normal wearout	62
Detected at scheduled maintenance	4
Worn, loose, missing	17
Improper maintenance procedure	2
Unscheduled maintenance activity, no degradation	233
Other	5
Total	763

A total of 70 incidents were presented for consideration at the extended testing RAM-D assessment conference. Of this total, 36 were excluded because system modifications had been applied to faulty components, which conference members believed would preclude recurrence. Thus, only 34 incidents were charged against the system and were used to determine the combat mission reliability estimate of 326 mean miles between failure.

Based partially upon the above data, in March 1980, the Deputy Secretary of Defense certified that RAM-D contractual requirements had been met and released the remaining M1 fiscal year 1980 funds.

NEED TO FULLY EVALUATE
TOTAL M1 LOGISTICS BURDEN

If a realistic assessment is to be made of the anticipated operational suitability of the M1 when it is operated and maintained by Army troops, phase III developmental and operational testing must be tailored to provide answers to the following key questions:

--Have previously identified tank hardware deficiencies been corrected, and has the M1 achieved the required level of maturity (RAM-D) to support a decision to proceed into full production?

--What are the operational characteristics of the M1, including the combined effects of item design and quality, installation, environment, operation, maintenance, and repair?

--What is the maintainability of the M1 when measured by mean time to repair estimates which are defined to include all maintenance and repair times for attached and detached parts of the tank's system (not just system downtime)?

--What will be the operational and maintenance costs of supporting the M1 when considering demonstrated (as opposed to projected) reliability of each major M1 subsystem or component (i.e., engine, transmission, thermal imaging system, turret hydraulics)?

--Can the M1 be supported and maintained in the field by Army personnel, with its current logistics support concept at an acceptable level of operational readiness?

--Have sufficient quantities of all required logistics support resources (i.e., spare parts, test equipment, and trained personnel) been identified and acquired to support M1 deployment and fielding?

EMERGING RESULTS FROM DEVELOPMENTAL
AND OPERATIONAL TEST III

Emerging results from developmental and operational test III indicate the following:

--Not all RAM-D requirements will be met during the current phase of testing.

--Continuing hardware failures will jeopardize the ability of the test to validate logistics supportability.

--The logistics burden for the M1 will be much greater than the M60's.

--Follow-on testing will be needed to validate design improvements, gather additional data for logistics evaluation, and identify and rank areas for future product improvement.

Current assessment of M1 RAM-D

System and mission reliability, power train durability, and the maintenance ratio (maintenance hours to operating hours) have not yet achieved required levels. Preliminary test results demonstrate the following:

--Mission reliability is supposed to be 320 mean-miles between failures; however, during operational and developmental testing, it was 296 and 344, respectively.

--The maintenance ratio is supposed to be 1.25, but operational testing has only demonstrated 4.07. Developmental testing has demonstrated 1.58.

--Durability of M1 tracks is supposed to be 2,000 miles, but only 850 miles is being demonstrated during testing.

--Power train durability is supposed to be a 0.50-probability of going 4,000 miles without a failure. Operational testing is demonstrating a probability of only 0.18, and developmental testing is demonstrating a probability of 0.48.

While there is no availability requirement, the 1973 M1 materiel need statement contained an inherent availability requirement of 89 to 92 percent. M1 inherent availability during operational testing is estimated to be 53 percent, and operational availability to be 42 to 44 percent.

Logistics supportability assessment is limited

Army officials told us that because of continuing hardware failures and immature technical manuals and test equipment, current testing will not provide all data needed to assess M1 logistics supportability.

As discussed in appendix I, because of the continued occurrence of design deficiencies and inadequate logistics support capability during previous testing, the Army has been unable to validate the types, quantities, and skill levels of personnel required to support the M1. While major design deficiencies appear to have been resolved, equipment failures continue. Evaluation of organizational level tasks (largely troubleshooting, fault isolation, and replacement of components) is hampered by the immaturity of test sets and technical manuals. The amount of off-vehicle maintenance being performed at the direct and general support levels is limited because contractors (1) are performing some tasks which will be performed by Army mechanics at

the direct and general support levels when the system is fielded and (2) are testing failed components for failure analysis and evaluation. As a result, it is unlikely that all data needed to determine M1 personnel requirements will be forthcoming from the ongoing tests.

M1 logistics burden greater than M60

In November 1979, the Army initiated a manpower and logistics analysis to quantify and evaluate the impact of fielding the M1 with various levels of RAM-D for 56 M1 components. As a part of this analysis, the following two logistics burden parameters were developed and are being measured during ongoing testing.

--Mean miles between essential maintenance demand is defined as the average number of miles traveled between requirements for maintenance manpower. This factor is similar to the measure of system reliability, but unlike the latter, it includes those incidents caused by maintenance or crew error.

--Maintenance manhours per mile is defined as the maintenance manhours required to support the system. This factor is similar in definition to the current M1 maintenance ratio, but it includes incidents caused by maintenance and crew error.

The following chart shows emerging data from this study.

Logistics Burden Parameters

Parameter	M60A1	M60A3	M1 Developmental test III	M1 Operational test III
Mean miles between essential maintenance demand	60	65	47	45
Maintenance manhours per mile	.17	.16	.19	.49

As indicated above, the M1 vehicle maintenance burden is greater than the M60's. These parameters do not, however, measure off-vehicle maintenance, which for the M1 is expected to be much greater than the M60's because of the increased numbers and complexity of tasks.

IS THE M1 READY FOR FULL PRODUCTION AND FIELDING?

In previous phases of the M1 program, decisions were made to proceed from one program milestone to another before tests

had adequately demonstrated that the tank and its support system could achieve sufficient levels of maturity. For example, the program proceeded from the engineering development to the production phase before phase II testing was completed--even though serious design deficiencies had been revealed. The M1 was type classified standard, even though RAM-D requirements had not been met and logistics supportability had not been demonstrated. Throughout the M1's development, the urgency of fielding a new tank has been the justification for pressing forward with the program despite such problems.

An evaluation of current M1 program milestones shows that this same momentum persists today. It is impossible at this point to assess the potential future impact of this momentum on operational effectiveness and life-cycle cost. However, the following are past examples where problems have resulted:

--The M60A2 tank was deployed to Europe in 1974 with serious hardware design problems and inadequate logistics support capability (trained personnel, test equipment, spare parts, and technical manuals). Support costs have been high, and the system has never outgrown its reputation as an unsupportable tank.

--Production delays in manufacturing fire control systems for the Army's M60A3 program have resulted in the Army storing hundreds of tanks because they cannot be fielded without fire control systems. The Army estimates that additional program costs of over $5.7 million will be incurred to preserve and complete the production of stored tanks. The developer and primary manufacturer of the fire control system is Hughes Aircraft Company. Hughes has also developed and is producing the thermal imaging system for the M1. This component and others, including the engine, are behind scheduled delivery. Army officials estimate that over 30 M1s are incomplete because they lack engines, transmissions, or thermal imaging systems.

Appendix III lists pertinent M1 program milestones and shows how some have recently been accelerated or delayed. Because of the immaturity of the M1 tank and its support system, our evaluation of key upcoming M1 decision points raises the concerns discussed below.

Increasing M1 production base capability

Although scheduled milestones for increasing tank production and deploying the M1 to Europe have been delayed, the original Army plans to develop production facilities have continued as scheduled. As currently scheduled, a second M1 production facility will begin M1 deliveries in March 1982, increasing production base capability (for a single shift production operation at both facilities) to 60 tanks a month by September 1982.

The original production schedule called for producing 110 M1s before March 1981. However, this number was reduced to 90 in 1981 because of cost overruns. As of April 1981, the Army had received 80 tanks. Currently, the Chrysler-operated Lima Army Tank Plant is producing about 10 to 15 M1s a month. Although the production rate was expected to be 30 a month at this time, tank production and quality control problems and delays in delivery of key components (i.e., engine, transmission, and thermal imaging system) caused delays in original production milestones. The rapid pace of the program has allowed insufficient time to resolve production problems. We believe that problems in production, deficiencies in quality control, and delays in delivering key components should be resolved before production is increased further.

Increasing tank production

Current tank production is below the 30-tank-a-month delivery schedule approved by the Army and DOD acquisition review councils in 1979. While early production delays are common for new, complex weapon systems, the wisdom of basing funding and other program planning decisions on potentially unrealistic goals appears questionable.

Even if tank production problems are resolved rapidly, the prudence of increasing tank production when the tank's operational supportability has yet to be demonstrated appears questionable. The impact will be to deploy a tank system that may (1) not be ready for combat when needed, (2) cause support costs to increase greatly, (3) require retrofit to achieve required design configuration, and (4) require modification of support elements.

Army officials stated that the key to the production build-up issue is the critical need to increase tank capability in Europe. However, there is some question as to how many M60 units in Europe can be effectively transitioned to the M1 in the first few years, given such limitations as training needs, range capability, and availability of support resources.

We believe that a decision to increase tank production to 60 tanks a month should not be made until the following factors are carefully considered.

--Since European deployment of the M1 must be phased, the number of tanks fielded in the first year may be less than the number of tanks which can be produced, based on the 30-tank-a-month schedule.

--Establishing overly optimistic production schedules is a high risk effort. As illustrated with the M60A3 program, storing and completing production of partially completed tanks is costly and is not an effective utilization of limited program dollars.

--An interim assessment of developmental testing by the Army's Material Systems Analysis Activity concluded that transition from "hand-built" prototypes to quality production tanks must still be demonstrated.

However, we also recognize the lower per-unit cost of more efficient production-run quantities should be considered and compared to the potential problems above.

<u>M1 deployment to Europe</u>

Army officials stated that from a user's perspective, the assessment of emerging test results indicates the M1 tank, "even at its current configuration and reliability level, has more operational utility and combat effectiveness than the current main battle tank."

While we recognize that the Army needs to deploy the M1 in Europe as quickly and in as many numbers as possible, we believe that a deployment decision should be made on the basis of demonstrated supportability criteria. It may not be sound, however, to replace an M60 unit with M1s which have far less potential to be ready when needed, even though M1s offer greater operational capability. Although intensive management and special procedures can be effective in increasing readiness, as demonstrated in the current testing environment which involves intensive and dedicated support, M1 operational availability may still not meet readiness requirements.

<u>Procurement of long lead items and spare and repair parts</u>

Requirements for long lead items and spare and repair parts are determined using optimistic production and fielding schedules. Since M1 production and fielding have been revised, current orders may already exceed the requirements of the current schedule. Future procurement of long lead items and spare and repair parts should be made only after the production schedule and the risks of obsolescence are carefully evaluated.

<u>CONCLUSIONS</u>

With M1 full production and deployment decisions approaching in September 1981, the Army has yet to demonstrate that the M1 can be sufficiently reliable, available, maintainable, durable, and logistically supportable to be operationally effective in a realistic field environment.

During previous testing, assessment of RAM-D and logistics supportability characteristics was limited by the establishment of insufficient criteria, failure to collect needed data, the magnitude of deficiencies in hardware design and logistics support capability, and other factors. In the past, the momentum of

the M1 development, in light of such deficiencies, has been justified based upon the Army's critical need to increase its tank capability in Europe. There is a need to reevaluate certain program commitments based upon the potential impacts of continuing the program as planned.

Emerging results of ongoing testing raise serious doubt as to the supportability of the M1. RAM-D requirements have not been met. But more importantly, failures which have not been assessed against the reliability of the M1 (based on current Army scoring criteria) may, in a realistic operational environment, present an even greater logistics burden.

Although the Army identified two additional parameters for evaluating the M1 logistics burden, it did not establish quantifiable goals or standards against which to measure test results. While this information will be helpful in evaluating M1 supportability, we believe additional criteria should be established.

The past is replete with examples of the adverse impacts of rushing forward with scheduled deployment and full production milestones without adequately considering the potential consequences. A realistic assessment of the current status of the M1 program may not support continuation of the M1 program as currently scheduled.

RECOMMENDATIONS

We recommend that the Secretary of Defense require the Secretary of the Army to:

--Establish additional criteria (at the system and subsystem levels) for evaluating tests that place greater emphasis on operational effectiveness measures and assessment of future support costs. This criteria should include goals and thresholds for logistics burden and operational availability.

--Quantify and evaluate the potential impact (in terms of increased support costs, retrofit costs, reduced operational readiness capability, etc.) of producing and fielding the M1 with currently demonstrated levels of RAM-D.

--Reevaluate current M1 program plans for increasing production capacity, monthly tank production goals, deployment to Europe, and acquisition of long lead production items and spare parts, considering the current level of design maturity of the tank and its support system, tank production and quality control problems, and other factors.

Also, because of congressional concern that the M1 had not demonstrated required RAM-D and logistics supportability, we recommend that the Secretary of Defense provide information to key congressional committees on the M1's logistics burden and

quantify (in terms of increased maintenance costs and reduced operational readiness) the effects of fielding the M1 system at its current level of maturity or of delaying the program.

AGENCY COMMENTS AND OUR EVALUATION

DOD agreed with our recommendation to establish additional criteria for evaluating ongoing tests and stated that two logistics burden parameters were established. While we believe these new parameters will provide better data for evaluating supportability, we believe quantifiable goals and thresholds should also be established.

DOD also agreed to quantify and evaluate the impact of fielding the M1 with currently demonstrated levels of RAM-D. We believe that the Congress should be informed of the results of the Army's manpower and logistics evaluation. We are concerned, however, that without additional quantifiable data to assess the total logistics burden, this evaluation will not be all encompassing.

DOD agreed in principle to reevaluate program milestones. At a special Army acquisition review council meeting on February 17, 1981, the Army reassessed the tank's maturity and logistics supportability and, in type classifying the M1, concluded that

--the majority of M1 development was reasonably complete, and planning was sufficiently mature to ensure adequate support for the M1 fleet;

--maturation of remaining items can be completed without undue risk to M1 readiness; and

--the M1 is supportable in the near term considering the relatively low production rate and intensive management of logistics issues.

On the basis of this evaluation, DOD said that the Army is proceeding with current program plans for increasing production capability and monthly production of tanks, deployment, and acquisition of logistics support. DOD said that adequate supportability testing information should be available for full production and deployment decisions scheduled for September 1981. Such decisions will include an evaluation of tank maturity, logistics support status, and associated risks.

Since adequate test information may not be available by September, we are concerned that program momentum may continue on the basis of optimistic projections. We believe key congressional committees should be provided with the information DOD uses to arrive at its full production and fielding decisions and should be apprised of the potential consequences of proceeding with these actions or delaying them.

CHAPTER 5

MAINTENANCE PLANNING: EFFORTS ARE UNDERWAY TO OVERCOME LATE START, BUT MORE NEEDS TO BE DONE

The objective of maintenance planning is to ensure that sufficient logistics support exists to maintain a weapon system at the highest level of readiness in the most efficient and economical way. By basing the planning on complete, documented LSA, the Army can determine the optimum mix of skilled personnel, technical manuals, special tools, test equipment, and repair parts needed for maintenance support and can ensure that repairs are made at the most economical maintenance level commensurate with readiness objectives.

The Army, however, has not done sufficient maintenance planning for the M1 tank program. Because the Army did not accomplish LSA early in the M1 program, it missed opportunities to correct maintenance design deficiencies and relied too much on depot maintenance, which can be more costly and less responsive than field maintenance. Moreover, M1 depot planning is incomplete because it received inadequate management priority. The schedule for complete in-house depot capability has slipped from 1981 to 1984, and the Army remains uncertain about what depot resources will be needed and when they will be available. Also, plans for obtaining contractor interim depot support are unsettled. Although efforts are underway to overcome the late start in maintenance planning, a more comprehensive and coordinated approach is needed.

LATE START ON LSA HAS IMPAIRED M1 MAINTENANCE PLANS

Maintenance planning for the M1 was not based on a documented LSA. Instead, planning evolved segmentally over a period of years. The untimeliness of M1 maintenance planning has led to shortcomings in the allocation of level of repair and has resulted in the development of design-dictated maintenance burdens.

Army policy requires that maintenance be done at the lowest possible maintenance level while still being consistent with the support system of the Army in the field. This policy is known as the forward repair concept and was based on the theory that doing repairs close to the using units minimizes equipment downtime and reduces costs. The maintenance levels, in ascending complexity of repair, are briefly described below.

--Organizational maintenance is done by unit mechanics or tank crews and involves inspections, minor adjustments, and replacements of readily removed components and parts.

--Direct support maintenance diagnoses and isolates equipment malfunctions and primarily replaces defective components.

--General support maintenance repairs components and does heavy body repairs.

--Depot maintenance overhauls end items and components, repairs items exceeding the capability or capacity of other maintenance levels, and modernizes equipment.

To comply with the forward repair policy, the Army must make an early LSA, including a repair level analysis, so that the system's design does not dictate maintenance requirements. This requirement is recognized in the M1's statement of materiel need which states that maintenance plans must be based on the forward repair concept and documented LSA.

Repair analysis begins by identifying which tank parts can be repaired and which maintenance level can do the repairs. Early identification of repairable parts and their assignments to the proper maintenance level is critical because such assignments dictate the type and amount of resources, personnel, and equipment needed for support.

The basic M1 maintenance concept was not based on a documented LSA; it evolved from the basic design of the prototype vehicle. In accepting the basic tank design in 1976, the Army also accepted the contractor's maintenance plan. The Army later found that the plan was incompatible with the forward repair concept. The contractor's maintenance plan was based primarily on the contractor's experience with the M60 tank. Although contracted for in 1976, LSA only documented the existing maintenance plan, not the maintenance assignments within the plan. As a result, the repair level analysis was not timely or complete. From 1976 until August 1980, when the list of repairable parts and maintenance assignments was made firm, confusion existed within the Army regarding how many M1 parts were repairable and where they should be repaired.

Additionally, because the M1 maintenance concept was not based on a documented LSA and LSA records were not established to provide a single source for the integration of M1 maintenance support requirements, different data sources were used as the baseline for resource requirements. The impact of this condition is discussed in succeeding chapters of this report.

Contractor's plan is inadequate

The Army's first broad-based review of the contractor's maintenance plan did not occur until October 1977, nearly 1 year after the Army had accepted the plan. After conducting a repair analysis of contractor maintenance assignments, the review group, including user representatives, concluded that:

--Maintenance assignments did not provide enough field capability, particularly at the general support level.

--Maintenance assignments provided unnecessary transportation of M1 components to the depot level for repair.

The group recommended that 104 repairable parts be reassigned from the depot level to the field or from one field level to a lower one.

The Army, however, was unable to reassign these parts because of the high costs involved; the contractor's price was $29.9 million, but the Army had budgeted only $4 million for maintenance reassignments. Therefore, the Army decided to add $3.7 million to the M1's logistics support contract in May 1979 and reassigned 26 of the 104 parts. These reassignments, however, did not include many high-priority items, such as the turbine engine and printed circuit boards, which the group believed should be moved forward. Field repair capability for these items has been deferred until 1982.

The Army reviewed the revised plan in September 1979 and informed the contractor that M1 maintenance assignments were still superficial and incomplete. As a result, the assignments for fielding were extensively revised and were published on August 1, 1980. Although these assignments do not include all the forward maintenance desired, Army officials consider them acceptable, given the time and money constraints.

<u>Opportunities for reducing M1 maintenance burden were lost</u>

While operators of the M1 told us that its operational effectiveness is far superior to existing tanks, maintenance technicians said that the M1 is poorly designed with respect to maintainability. If a repair level analysis had been made early in the program, the design of some M1 components could have been modified to minimize maintenance. We identified six such components, including wiring harnesses, hydraulic connectors, fuel filters, air filters, forward fuel tanks, and gun mounts and breeches. The last two items are discussed below.

--The Army only recently changed the maintenance assignment for replacing M1 forward fuel tanks from the field to the depot level. Although fuel tanks, such as those in the M60 tank, are normally replaced in the field, the M1's fuel tanks must be replaced in the depot because they are placed in the hull and cannot be removed without cutting the tank's armor. Because repair analysis was late, this design-dictated maintenance was not identified in the tank's design phase when options could have been considered.

--Because of the M1 turret's design, removing the gun mount and breech may not only require more maintenance than a M60 tank, but it may also expose Army mechanics to physical danger. On the M1, the gun mount and breech must be removed through a turret hatch, which entails passing

a 500-pound piece of steel through an opening just large enough for a soldier to go through. The mechanic must work behind the gun's recoil spring where a small error could release the spring with enough force to crush the mechanic. On the M60, the gun mount and breech are removed through the front of the turret. Some Army officials claim the M1 turret's narrow gun opening will enhance crew survival. ARRCOM officials disagree and have suggested a gun shield redesign which will enlarge the opening without degrading survivability. These officials stated that front removal of the gun mount and breech would enhance combat maintainability, improve safety, and reduce the number of special tools required.

The M1 program office is convinced that the existing gun shield and rotor design and maintenance concept for removal of the gun mount and breech are valid. Officials at ARRCOM, the Ordnance Center and School, and the DARCOM Materiel Readiness and Support Activity, however, want the design changed to increase safety. While redesign of the turret at this time may not be practical for the current M1 configuration, the Army may still have ample opportunity to adopt an improved design for the M1E1 configuration which will incorporate the 120-millimeter gun.

Army efforts to reduce M1 maintenance burden

Design-dictated maintenance burdens can rarely be resolved except through equipment redesign. Once systems are in production, however, such redesign is expensive and creates additional problems resulting from the fielding of equipment with different configurations. Recognizing that maintenance problems exist with the M1, the Army has initiated a program to reduce the maintenance burdens. Proposed design improvements include an improved air induction system, lower maintenance fuel system, relocated hydraulic pump, simplified fire control hydraulics, and other items. Estimated costs exceed $79 million. Other M1 design improvements were proposed to provide greater maintainability.

M1 DEPOT PLANNING IS INCOMPLETE

According to Army regulations, a depot maintenance support plan, which includes acquisition, scheduling, and training requirements, must be prepared. Preparing this plan requires close coordination with the Army's weapon system program manager, responsible materiel readiness commands, and depots. However, the plan was started late for the M1 program and, as of April 1981, was incomplete.

The first M1 depot maintenance support plan was published in 1978. This plan established April 1981 as the milestone for achieving complete in-house depot capability. But, because of the low priority given to M1 depot support and funding problems, the milestone for total in-house capability has slipped

until 1984, certain program activities have been delayed, and production hardware has not been available. The results have been confusion in M1 depot planning and increased reliance on contractor support.

Before the M1 technical support contract in 1979, the identification of M1 depot requirements received little attention beyond identifying the components assigned for depot maintenance. Because of insufficient funds and an immature tank design, depot maintenance was not included with field maintenance in the Army's 1976 logistics support contract with Chrysler. If detailed depot maintenance planning had begun earlier, maintenance capability in both the depot and the field would have benefited and the Army's 1977 attempt to move depot tasks forward for field repair would have been implemented more readily.

In addition, an earlier start of M1 depot planning could have provided the Army more opportunity to evaluate savings available through the use of existing depot resources. As required, the Army made an interservice review of existing depot facilities, but severe time constraints and limited technical data prevented it from making an indepth study. As a result, other military services submitted only limited support proposals, and the review group had little choice but to recommend the more thoroughly developed Army proposals.

Funding problems

The acquisition of M1 depot maintenance plant equipment and the writing of depot maintenance work requirements have been delayed because of Army funding problems. Funding for depot equipment--the specialized machinery needed for the M1--was identified as a problem during the Army's February 1979 M1 logistics readiness review. In fiscal year 1979, depot equipment funding changed from the operations and maintenance budget to the procurement account, but funds were not transferred. However, the Army failed to adequately anticipate the impact of this change on depot equipment funding and, as a result, could purchase none of the planned M1 depot equipment in 1979.

Although the Army has tried to correct this problem, doubt still surrounds depot equipment funding. In fiscal year 1981, ARRCOM planned to fund $9 million for M1 depot equipment needed for five of seven major turret subassemblies. However, the availability of this money remains uncertain. Even if money is available in fiscal year 1981, firm cost data and equipment delivery dates have yet to be finalized. ARRCOM officials stated that some funds had been obtained by mid-January 1981, but not enough to meet total requirements. Any further delay in obtaining depot equipment would mean a comparable delay in achieving in-house capability.

The writing of depot maintenance work requirements for M1 components was originally scheduled to begin in November 1978,

was slipped to August 1979, and was finally begun in early 1981. These requirements, which document work procedures for accomplishing depot level maintenance, have been delayed because of insufficient Army funds. After the contractor submitted a bid of over $2 million to write requirements for only the M1 engine and transmission, the Army decided to do this work in-house. In addition to the engine and transmission, work requirements must be identified for 77 other M1 hull and turret components. For major hull systems, depot work requirements will be prepared in-house, while for turret systems, they will be prepared by the contractor.

Production hardware not available

Without production hardware and associated technical data, depot planning activities cannot identify the specific resources--work requirements, automatic test equipment, special tools, and training--needed for depot overhaul. In a September 1980 memorandum, Army officials stated that in-house capability is directly dependent on the availability of hardware.

As of April 1, 1981, M1 production hardware delivery schedules were improving, but they were still far short of meeting requirements. An ARRCOM official stated that the current technical data package was far below required standards. For one major subsystem, the thermal imaging system, information in the technical data package more closely related to the subsystem's configuration in 1978 than to the current production tanks' configuration. Without having access to hardware, depot planning officials cannot possibly assess the full extent of the deficiencies in the current technical data package.

According to Army officials, the establishment of a parts allocation board should provide the intensive management required to distribute M1 components and parts. Additionally, action is underway to procure an updated version of the M1 technical data package.

Confusion over depot maintenance
for the M1 turbine engine

The need for more management attention to depot planning is particularly apparent from the Army's problems in assigning depot maintenance for the M1 turbine engine. Normally, a tank's engine is maintained at the depot having primary responsibility for that vehicle, but a turbine engine has unique maintenance requirements compared with the diesel engines of other tanks, such as the M60.

Plans for worldwide depot maintenance of the turbine engine have been conflicting. The M1 development plan shows that Mainz, West Germany (the Army's overseas tank depot), has complete M1 engine overhaul responsibility for European-based tanks and that Anniston, Alabama (the Army's stateside tank depot) has shared responsibility with the depot in Corpus Christi, Texas, for engine overhaul of U.S. based tanks.

A November 1979 review by the Maintenance Interservice Review Group 1/ recommended that all M1 turbine engine component/parts requiring depot maintenance/overhaul, including all reclamations, should be assigned to the Corpus Christi Depot. A January 1980 letter from the Assistant Secretary of Defense to us stated that the Corpus Christi Depot was selected to perform repair/overhaul of the M1 turbine engine. However, Army officials later told us that this information was incorrect and that the Anniston and Mainz Depots will have M1 engine overhaul responsibility and will receive assistance from the Corpus Christi Depot for performing reclamation for unique turbine engine parts.

A DOD official told us that while the Anniston Depot will be responsible for overhauling the turbine engine, up to 30 components may be overhauled at the Corpus Christi Depot or at subcontractor facilities. However, Corpus Christi Depot officials report having no final work description for M1 engines, no blueprints for special tools needed to overhaul the engines, and no guidance on what size workload to expect.

Until detailed depot maintenance plans are formulated and in-house capability is developed, contractor support for the turbine engine will be required.

Contractor support extended

Current Army estimates call for full in-house depot capability in 1983 at Anniston and in 1986 at Mainz. The new estimates reflect the need for continued contractor support, at least until the mid-1980s, for some M1 hull components. Several Army officials consider this milestone extremely optimistic.

Due to this delay, the Tank Automotive Command (TACOM) and ARRCOM revised their projections to extend contractor support on a component-by-component basis. ARRCOM is negotiating agreements with individual subcontractors and is tailoring the extended support to anticipated in-house capability for each component. TACOM is relying on an M1 program management contract, which ends in January 1982, with the prime contractor.

Interim depot contractor support may be a practical alternative to organic depot support early in the operational phase of a major weapon system program. For the M1, however, initial program plans provided for full Army depot capability before deployment of the tank. When the Army realized that additional

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1/The Maintenance Interservice Review Group was chartered in 1976 by the Joint Logistics Commanders to review depot maintenance requirements for new weapon systems and equipment. The purpose of its review is to expand the use of interservice support and thereby avoid unnecessary investments in depot support capability.

contractor support would be needed, the Army had little room to negotiate because the major contractors had exclusive services which it badly needed. According to ARRCOM and TACOM officials, in some cases, contractors may require additional facilities and overhaul costs will be high, but at this point, the Army has few options.

More effective maintenance planning, more realistic assessment of achievable milestones for full organic depot capability, and earlier negotiations for contractor support could have mitigated these problems and could have reduced depot maintenance support costs.

CONCLUSIONS

By not making an early LSA, the Army lost opportunities to correct design-dictated maintenance problems before full production began. Even the most recent revision of the M1 maintenance assignments does not solve the problem of insufficient field repair capability because the Army did not have enough money to reassign parts from the depot level. Therefore, the Army plans to field the M1 under a depot maintenance plan which does not reflect field repair capability satisfactorily and then to correct maintenance problems in the field. This may not be a cost-effective approach because manuals must be rewritten, troops must be retrained, new tools must be stocked, and parts must be maintained for multiple configurations of the M1.

Moreover, the M1 depot maintenance plan is incomplete because it assigned a low priority to depot support. In view of the Army's insufficient planning, the Army's goal to have complete in-house depot capability by 1981 appears to have been unrealistic. The funding problems which have delayed acquisition of depot equipment and completion of depot work requirements, as well as the limited depot experience with M1 production hardware, cast considerable uncertainty on when complete in-house capability will be available. Meanwhile, the Army is dependent on depot support from contractors, regardless of the cost.

Inadequate attention to maintenance planning and development, for the M1 program and other weapon system acquisition programs that we have reviewed, has continued to be a problem. For future systems, to optimize ILS planning and provide more supportable systems at reduced life-cycle cost requires earlier and more effective maintenance planning.

RECOMMENDATIONS

We recommend that the Secretary of Defense require the Secretary of the Army to:

--Direct that maintenance planning in future development programs be adequately done to minimize design-dictated maintenance, to ensure cost-effective field repair capability, and to provide timely transition from contractor depot support to in-house capability.

--Increase support for the development, testing, and evaluation of M1 maintenance capability at all levels to identify deficiencies in the tank hardware or its support system which will result in increased maintenance cost or decreased operational readiness and initiate corrective action as required.

--Expedite the development of in-house depot level capability for the M1.

AGENCY COMMENTS

DOD agreed to provide increased emphasis and resources, if needed, for the development, acquisition, and evaluation of required logistics support capability. DOD said the logistics support elements are being evaluated in current testing and correction of any remaining deficiencies in these important areas will continue to receive emphasis. DOD did not comment on our other recommendations.

CHAPTER 6

THE ABILITY OF TEST EQUIPMENT AND TECHNICAL MANUALS TO SUPPORT THE M1 IS UNCERTAIN

Effective maintenance planning, as discussed in the previous chapter, should enable the Army to determine those resources needed to support a weapon system. Two important resources are test equipment and technical manuals; they must be of sufficient quality and quantity to support weapon system testing, training, and field maintenance activities. At the same time, their costs should be kept as low as possible through efficient management.

Because logistics planning for the M1 was insufficient and late and prototype tanks were not available when needed, the development of M1 test equipment and technical manuals lagged behind tank hardware development. As a result, excessive costs were incurred and support resources of questionable quality were produced. Also, inadequacies in the test equipment and manual programs adversely affected logistics support development and testing. Although the Army is trying to correct these deficiencies, neither the test sets nor the manuals have yet demonstrated required maturity. Before needed support for a fielded M1 can be certain, many questions must be answered about the adequacy and availability of test equipment and technical manuals.

MORE REALISTIC PLANNING AND REQUIREMENTS NEEDED FOR M1 TEST EQUIPMENT

Because the M1 is a more sophisticated armored system than those previously fielded, the Army identified an increased need for automatic test, measurement, and diagnostic equipment to more quickly and accurately isolate faults in M1 systems and components. However, M1 test equipment quality and availability have suffered due to initial planning, development, testing, and funding deficiencies. Although the Army has attempted to improve test set performance, the remaining problems raise questions about the ability of these test sets to adequately support European fielding as currently planned.

Problems in early test set development and testing

According to the Army's contract with Chrysler, M1 test sets were to be designed through the LSA process and were to be developed to conform with the M1 maintenance plan. But, because LSA has been ineffective, test sets have not been developed as an integral part of the tank hardware design effort, have lagged far behind schedule, and still require improvements before they can effectively provide needed support to achieve desired M1 field maintenance capability.

Chrysler originally developed eight types of test sets to support M1 field maintenance. These test sets were to be pretested in a facility vehicle test, training courses, and the physical teardown/maintenance evaluation. However, since the contractor did not have a prototype tank available to support these activities, it did only minimal testing of the test sets. The physical teardown/maintenance evaluation, conducted in early 1978, was the first opportunity for Army mechanics to match the test sets with the tank. Although many compatibility and functional deficiencies were identified during the evaluation, there was not enough time to redesign and modify the test sets before phase II developmental and operational testing began in 1978 and 1979.

As a result, most of the test sets could not be effectively used in maintaining the M1 during phase II testing. Some properly functioning components were incorrectly diagnosed as faulty, and faults in improperly functioning equipment sometimes could not be identified. Testing also found that the test set design concept was frequently faulty. For example, the engine test set could function only when the engine was operating at almost full power. Test set capability was insufficient to allow isolation of faults to a single component and test points were inaccessible.

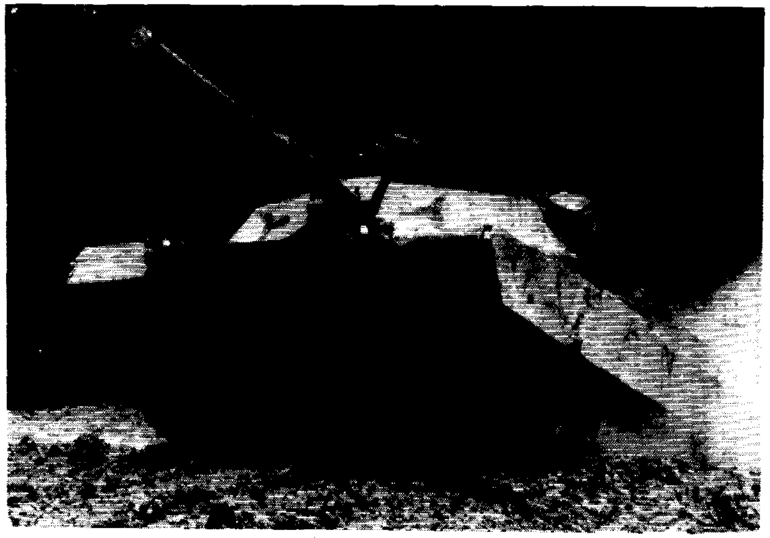
In view of the major problems identified in the first M1 test equipment development effort, the Army took corrective action in 1979 by initiating a $12 million program to consolidate and redesign the test equipment and a $1.2 million program to develop backup manual fault isolation procedures (known as alternate troubleshooting procedures). Earlier troubleshooting capabilities were expanded, and the previous eight types of test sets were consolidated into the three types of field repair units discussed below. (See photographs on p. 51.)

Current status of test set development

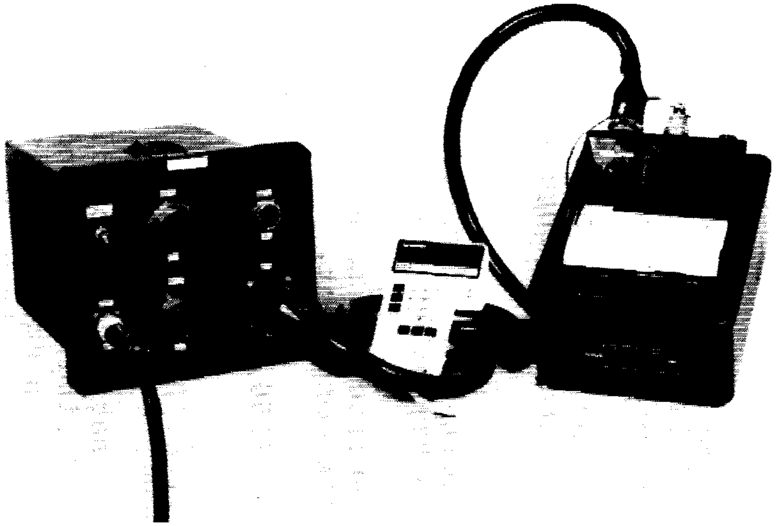
Although the redeveloped M1 test sets appear to be an improvement over the original eight units, early phase III developmental and operational testing indicates that many of the previous deficiencies have not been corrected and that complex problems must still be resolved before the M1 test set program can be viable.

Simplified test equipment/M1

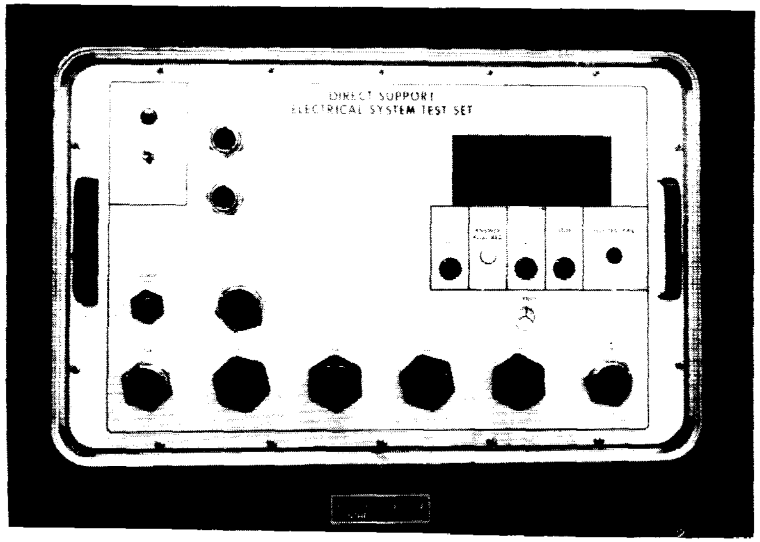
The simplified test equipment/M1, a modified version of an Army standard test set, is used primarily at the organizational level of maintenance to test about 35 tank systems and subsystems, including the engine, transmission, hull and turret electrical, turret stabilization, auxiliary hydraulic, fire control, computer system, cables, electronic boxes, and sensors. This equipment is housed in seven large, bulky cases and includes about 140 adapters.



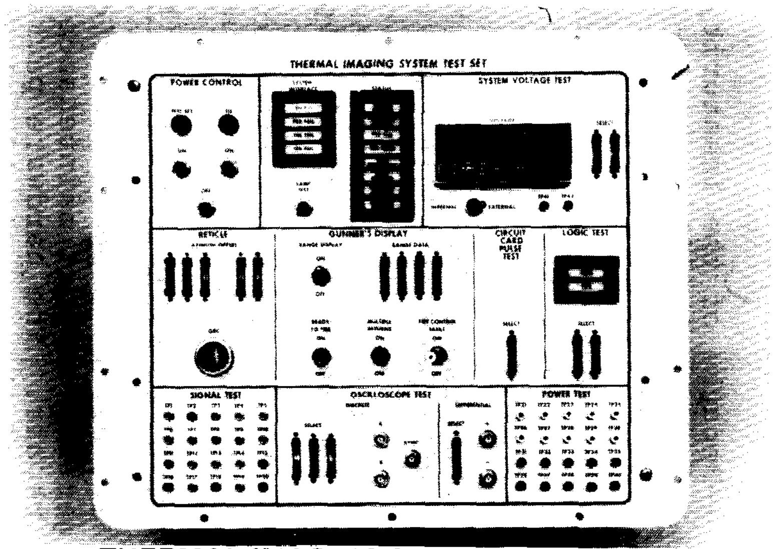
MI TANK



SIMPLIFIED TEST EQUIPMENT/MI



DIRECT SUPPORT ELECTRICAL SYSTEM TEST SET



THERMAL IMAGING SYSTEM TEST SET

According to Army personnel, who have used the simplified test equipment/M1, there are many problems. The following are examples of such problems.

- --Because of the immaturity of the test set software and incompatibilities between the test sets and technical manuals, troops are often unable to isolate faults.
- --The test equipment is voluminous and bulky, requiring excessive time to get it into the tank and properly attached.
- --Because of the large number of test sets, fielded units will need an additional truck to transport the equipment.
- --Test set capability often is insufficient to allow fault isolation to a single replaceable component.
- --The equipment is expensive (over $150,000 each), and troops are hesitant to use it.

Direct support electrical test set

The direct support electrical test set is used by direct and general support maintenance levels during testing and component repair. The hardware packaging of this equipment is superior to that of the organizational level test sets; however, the software capability is inadequate to isolate faults in all systems designed for field repair. Furthermore, because only limited direct/general support maintenance is being accomplished during ongoing developmental and operational testing, the equipment may not be sufficiently tested to isolate potential deficiencies.

Thermal system test set

The thermal system test set will be used at the direct and general support levels to isolate faults in the thermal imaging system. The interim set currently in use must be used with components of the tank as a "hot mockup" system. According to Army personnel, the existing equipment has worked fairly well, considering its limited capability.

The new thermal system test set has been delayed because of constant changes to the configuration of the thermal system itself and because of major design deficiencies in the prototype test set.

Army officials estimate that the thermal test set redevelopment will be completed in 1981 and that production test sets should be available for fielding in late 1982. However, anticipated cost increases (current estimates are $400,000 for each unit) may preclude the acquisition of sufficient quantities. Until the new thermal system test set is produced, the hot mockup

system will be used. However, there are only five units to support testing, initial fielding, and training requirements. Also, these interim test sets will not identify faults in all thermal system components.

Problems remain which must be resolved

Due to the M1's high degree of complexity, sophistication, and integration, effective and properly functioning test sets are essential at all levels of maintenance. According to Army officials, M1 test sets are not the single connection, small, simple test sets which were expected.

A January 1981 independent evaluation of ongoing operational testing at Fort Knox, Kentucky, by the Army Operation Test and Evaluation Agency stated that M1 "* * * test and diagnostic equipment is of little value in its current state of development." A March 1980 logistics status review of the M1 program by the DARCOM Materiel Readiness Support Activity stated that support and test equipment is a major problem which may significantly degrade M1 supportability when fielded.

Deficiencies in the current test set program include the following:

--Troubleshooting without test sets is required to supplement use of the the automatic equipment. Additional instructions and special tools are needed.

--Higher skill level troubleshooters are needed to perform certain tasks.

--Test sets can only operate sequentially. They cannot randomly allow access to a given component to isolate faults nor override a malfunction to complete a checkout.

--The capability and capacity of current software must be expanded.

Another problem concerns the repair and calibration of test sets. Since this equipment is expensive and limited numbers of sets will be available, an effective maintenance concept for the tests is needed. However, as of April 1981, there was no skill specialty available in the field to repair M1 test sets, and no test set instructional courses were initiated. Because test set density is low and contractor personnel are readily available to accomplish needed repair, the Army does not consider this to be a critical deficiency. However, this problem must be resolved before fielding the M1.

In addition, there are other problems that must be overcome if the M1 test set program is to be effective in supporting M1 maintenance requirements.

Maintaining configuration control

A major problem encountered during the M1 test set redevelopment program was the need to continually modify test set software (computer programing) procedures to conform with the constantly changing tank configuration. During ongoing tests, three modification periods have occurred, involving hundreds of changes. Keeping track of tank design changes and ensuring that appropriate modifications are made to all affected test sets will be a difficult and challenging task, as well as an expensive one.

In addition, although the M1 has been "type classified standard," production tanks, which have been produced thus far, are not the same configuration. However, M1 test set capability does not provide for multiple configurations. As additional tanks and test sets are produced, configuration control will become more and more critical. We believe the Army should consider all alternatives including:

--standardizing all tanks and test sets to a single configuration,

--providing different test set models for each tank configuration, or

--providing test set software capability in one model to accommodate multiple tank configurations.

Inadequate program funding

In 1979, $12 million originally allocated to the M1 test equipment program was reallocated for tank hardware development. As a result, the Army could not develop some test capabilities needed in the field, had to reduce the number of sets to be procured, and could not procure test sets needed to support maintenance during the first year of fielding in Europe. Procurement contracts for organizational and direct/general support production test sets were signed in November 1980, and Army officials estimate it will take 15 months before the production test sets can be delivered.

According to Army officials, 15 prototype test sets, which were delivered in 1980 to support M1 testing and training activities, will be diverted from these activities and sent to Europe to provide needed interim field capability. However, the number of sets to be made available in this way can accommodate less than 75 percent of the European fielding requirements. These requirements had already been reduced because of inadequate funding. Therefore, considering the amount of test equipment available for fielding, Army troops may be unable to provide adequate maintenance support. Army training personnel have also expressed concern over the proposed diversion of test sets from ongoing testing and training activities.

Alternate troubleshooting procedures

The nonavailability of properly functioning test equipment and the resulting inability of Army soldiers to do maintenance during previous M1 testing prompted the Army to develop alternate troubleshooting procedures. These manual procedures are intended to be used as backup in the field when the automated test sets do not work or are not available.

Although the alternate troubleshooting procedures were developed for use by Army mechanics having a skill level above that generally available in current units, the procedures have not been validated. Furthermore, the special tools and equipment currently authorized for field level maintenance units may be insufficient to accommodate the new procedural requirements.

Careful verification of alternate troubleshooting procedures is needed to ensure their viability. If deficiencies are identified which cannot be overcome, the Army may have to increase test set requirements to provide additional units in the field.

Corrective actions undertaken but more needs to be done

Recognizing the criticality of test sets in supporting the M1, the Army has initiated corrective action. Millions of dollars have been budgeted for future test set improvements. The alternate troubleshooting procedures will be evaluated during the M1 technical manual validation/verification. Additional special tools needed for troubleshooting are being identified and placed on contract. Redesign of the simplified test equipment/M1 hardware will be further evaluated.

A configuration management plan is being developed to address the ability of M1 test sets to keep current with multiple tank configurations. As the tank changes, configuration or test set software programs are improved, and software adjustments will be made by contractor personnel.

We believe that these are positive steps toward resolving M1 test set deficiencies, but we believe more intensive management of the test set program, as well as additional funding, is needed. The Army should make a realistic assessment of the current status of the M1 test set program and devise a detailed "get well" plan to formulate actions to achieve needed improvements.

M1 TECHNICAL MANUAL DEVELOPMENT LAGGING FAR BEHIND HARDWARE DEVELOPMENT

Technical manuals are the foundation of Army training and field maintenance activities. However, the development of M1 technical manuals has lagged far behind M1 hardware development. Although some time lag appears inevitable, earlier and more effective LSA and the acquisition of a prototype vehicle for

development and testing activities would have minimized the delay and would have helped to provide more accurate and complete manuals.

In an attempt to improve the quality and completeness of technical manuals, Chrysler produced several different drafts of the 51 M1 manuals. According to Army officials, the draft manuals, published in late 1980, were an improvement over earlier versions. However, early phase III developmental and operational testing has demonstrated that the quality of the manuals may still be far below that needed to support the M1 in an operational environment. A February 1980 logistics status review by the DARCOM Material Readiness Support Activity stated that M1 technical data (manuals and troubleshooting procedures) were a major problem that would significantly degrade M1 supportability when fielded.

The skill performance aid approach

The M1 is one of the first major Army systems to use the skill performance aid approach for developing technical manuals. The skill performance aid approach is intended to develop accurate, readily comprehensible manuals by using illustrations to clarify simplified, step-by-step operating and maintenance procedures. Although front-end analysis (which is intended to be an integral part of LSA) and a validation process are important to this approach, they have not been effectively carried out for the M1 program.

The effectiveness of front-end analysis depends on the development of baseline LSA records which identify all tank systems and components, their relationships, and the maintenance levels where they will be repaired. By obtaining data on operation and maintenance tasks, special tool and repair parts requirements, and other requirements from the LSA records and by basing the procedures to be entered in the technical manuals on appropriate repair level assignments, front-end analysis can ensure the development of accurate manuals to support required maintenance and training activities. However, as discussed earlier, LSA was not effectively implemented. The development of maintenance procedures and technical manuals were, to a large degree, different and uncoordinated processes.

Front-end analysis includes a behavioral task analysis in which manual developers are required to carry out the operating and maintenance procedures to determine the best way to portray them with appropriate illustrations. But, because the Army did not procure a prototype vehicle to be used for developing logistics resources, this task analysis was not done for the M1.

The skill performance aid concept provides that technical manuals be validated by Army troops before final manuals are produced and before the weapon system is deployed. The purpose of this validation is to ensure that the procedures are accurate and easily comprehensible and that the intended user can implement

them. Again, because a prototype vehicle was not available when needed, the validation of M1 technical manuals was delayed. As a result, manuals were later found to be inadequate for supporting required training and testing activities.

Deficiencies in early M1 technical manuals

During the 1978 maintenance evaluation, early drafts of M1 technical manuals were found to be incomplete, incorrect, and incompatible with the latest M1 tank configuration. They contained errors and omissions in preliminary procedures, tool requirements, and repair actions. They were also poorly organized and too frequently referenced other manuals, which required the maintenance technician to change from one manual to another in the course of a single maintenance action. The problem was further complicated by poor indexing and tables of contents.

Due to insufficient time between the maintenance evaluation and phase II developmental and operational testing, the same deficiencies were encountered. In fact, the draft manuals were of such poor quality that Army maintenance technicians could not carry out necessary maintenance activities, and technicians had to call in contractor personnel to keep the tanks operational. The poor quality of M1 manuals also minimized their effective use in early M1 training.

Current status of technical manual development

In the fall of 1980, before phase III developmental and operational testing, Chrysler and the Army devoted increased management attention to improving the quality and completeness of M1 technical manuals. Army officials at numerous activities reviewed previous drafts and made recommendations for corrections and improvements. However, the manuals have still not been validated, as required by Army regulation. Army officials stated that the validation process was to be initiated at Fort Knox, Kentucky, in February 1981 and at Aberdeen Proving Ground, Maryland, in July 1981. The process is projected to take 12 to 18 months to complete. After the process is completed and the required review and revisions are made, the Army will publish final manuals. Until that time, existing draft manuals (with periodic updates) will be used for training, testing, and field maintenance activities.

According to Army officials, early phase III developmental and operational testing indicates that, although the latest draft manuals are better than previous versions, they are still deficient in many respects. For example:

--Troubleshooting procedures are incomplete and are difficult to follow.

--The manuals appear to have been developed segmentally, and the segments contain discontinuities and inconsistencies in terminology and procedures.

--Many of the manuals are still poorly organized.

--Because the maintenance procedures have been developed from hardware drawings and have not been verified on the tank itself, they frequently are inaccurate and do not correctly specify required tolerances, needed repair parts, test equipment, or special tools.

--Maintenance procedures often do not address the latest tank configurations or test set procedures.

--Because maintenance repair level assignments are still changing, appropriate modifications are frequently not yet reflected in the manuals.

--In many instances, more detailed technical schematics are needed rather than the simple line drawings which are currently used.

--The manuals contain numerous technical and typographical errors.

--Crew manuals are too bulky.

Because the M1's configuration is continually modified to correct hardware design or production deficiencies, M1 technical manuals must be altered appropriately. In view of this task, as well as the task of correcting those deficiencies already identified, the validation process, as currently scheduled, may have to be extended.

CONCLUSIONS

The lack of adequate front-end logistics support planning and the failure to dedicate sufficient program resources in a timely manner to developing and reviewing logistics support capability have adversely affected the development of M1 test equipment and technical manuals. Although improvements have been made as a result of increased program emphasis in these areas, ongoing developmental and operational testing has demonstrated that progress has been limited and serious deficiencies remain. These deficiencies must be overcome if the Army is to achieve sufficient maintenance support capability.

Progress in resolving previously identified deficiencies has been slow, in our opinion, largely because the testing and evaluation of logistics support capability continue to take a back seat to the problem of resolving tank hardware design and production deficiencies. As discussed in previous chapters, earlier Army and DOD decisions allowed the M1 program to enter the production

phase even though the maturity of the M1 tank hardware and of its support network had not been adequately demonstrated in testing.

If required emphasis (as specified in existing DOD directives and Army regulations) had been placed on the development, testing, and evaluation of test equipment and technical manuals, the Army would be in a better position to determine the practicability of the M1 maintenance plan and the logistics supportability of the M1 in an operational environment.

We believe that the identification and correction of deficiencies in M1 test sets and technical manuals must receive increased management attention.

RECOMMENDATIONS

We recommend that the Secretary of Defense require the Secretary of the Army to:

--Increase support for the testing and evaluation of M1 test sets and technical manuals to develop them sufficiently to support maintenance activities in the field.

--Validate test set requirements to ensure that (1) sufficient numbers of units will be available to support initial deployment without adversely affecting training and testing and (2) long-term test set requirements are based on realistic factors (maintenance staff-hours, etc.) and sufficient test sets will be available to provide operational readiness.

--Conform M1 test sets and manuals with M1 hardware configurations and develop maximum tank standardization to mitigate the support problems inherent in multiple M1 configurations.

--Conform M1 technical manuals to the skill performance aid standards and adequately validate them before fielding.

--Provide sufficient program resources, including a prototype vehicle, if needed, and direct increased management attention to the development of technical manuals and test equipment during prototype development in future programs.

AGENCY COMMENTS

DOD agreed to provide increased emphasis and resources, if needed, for the development, acquisition, and evaluation of required M1 logistics support capability. DOD said the logistics support elements are being evaluated in current testing and correction of any remaining deficiencies in these important areas

will continue to receive emphasis. DOD did not comment on our other recommendations.

CHAPTER 7

SAVINGS POSSIBLE IN THE PURCHASE OF SPARE AND REPAIR PARTS

Because of increasing budget constraints and the increased number and complexity of new weapon systems, it is vitally important to determine the most cost-effective use of spare and repair parts. History has demonstrated that many of the spare parts which are procured early in the production phase of a major new weapon system become obsolete. DOD and Army guidance for determining initial provisioning requirements provides for minimizing early spare and repair part procurements until a more stable design and fielding plan are achieved.

Primarily because the needed data was not available, the Army was largely unsuccessful in using standard systems for determining initial provisioning requirements for the M1. The systems that were used to determine parts requirements for the first 3 years of production resulted in the procurement of spare and repair parts which may greatly exceed the actual requirements for that period. Furthermore, because of continuous engineering design and tank production changes, many of the spare parts procured may already be obsolete or may become obsolete as the tank design changes.

Verification of M1 initial provisioning requirements, along with an evaluation of the compatibility of spare parts with production components, is needed. Future spare and repair part purchases should be adjusted appropriately. Additionally, alternative procurement strategies, some of which the Army is currently considering, offer potential for substantial savings in future procurements.

ARMY STANDARD PROVISIONING METHODOLOGY NOT FULLY IMPLEMENTED

In compliance with DOD policy, the Army developed the "Automated Requirements Computation System Initial Provisioning" computer program to do provisioning (the process of determining and acquiring the support items and technical documentation needed to operate and maintain the tank). Because it is difficult during the development phase of a weapon system program to determine how often items will fail and other factors which will effect anticipated demand during the system's operational phase, the standard provisioning system provides for minimizing the quantities initially procured, based on failure factor predictions, until the equipment is fielded and actual demand data is collected. The system also recognizes that, during the first few years of production, configuration changes may result in considerable changes to earlier predictions of spare and repair parts requirements.

However, partially due to the M1's compressed development-to-fielding schedule, key logistics data and provisioning documentation were unavailable when needed, and the standard system could not be used for initial M1 provisioning. Missing documentation and data included

--an accurate description of the tank configuration,

--a coordinated fielding plan and a realistic tank production schedule,

--a definite maintenance concept,

--engineering estimates of failure rates for repair items, and

--realistic costs for systems and components.

Much of the data was unavailable because of delays in performing LSA. As previously stated, the Army did not contract for LSA until November 1976, and the contractual agreement reached between the Army and Chrysler did not provide for a complete LSA. The agreement did establish milestones for Chrysler to begin submitting provisioning technical documentation in June 1978 and for the process to end in December 1979.

First submissions were in December 1978, but as of December 1980, the delivery of data to do provisioning was still not complete. Army officials told us that, besides being late, the technical documentation submitted was often inaccurate or incomplete and had to be sent back for correction. Errors included unrealistic maintenance factors, repair levels, and unit prices; failure to identify all reparable components; and omission of key factors on which to compute spare and repair parts requirements. Futhermore, technical information related to the hundreds of configuration changes was not processed in time to adjust spare and repair parts procurements.

As a result, Army activities used several alternative provisioning methods in attempting to comply with Chrysler's deadline for ordering spare and repair parts from subcontractors. The following are some of the alternatives used.

--The M1 program office identified spare and repair part requirements, totaling $33.2 million, to support training and testing activities during the first year of limited tank production. These requirements were identified mostly by using the contractor's recommendations.

--TACOM used four methods to determine parts requirements for the first year; but, after encountering many early problems, it was finally successful in using the standard provisioning system for almost all items. According to TACOM officials, if early provisioning efforts identified

excessive requirements, the subsequent automated procedures should have reduced them by the appropriate amount. For its eight primary, high-value items, TACOM used a special spares optimization model designed to compute large quantities during the initial program years to allow for safety level stockage. To meet initial provisioning requirements for the first 3 years of deployment, TACOM identified spare and repair parts requirements valued at over $183 million. These requirements were based on a tank production and fielding schedule which is no longer current; however, $180 million of these parts have already been placed on contract.

--ARRCOM has purchased spare and repair parts, valued at over $141 million, to support initial provisioning requirements for tank turret items for the first 3 years of fielding and has identified requirements for an additional $71.5 million. ARRCOM used the spares optimization model to determine almost all spare parts requirements. Additionally, ARRCOM used other techniques to generate additional requirements. For example, three extra quantities were bought of every item for each of the first 2 years. ARRCOM officials said these quantities were ordered to cover such things as potential breakage and damage of parts during shipment and to replace parts which could be damaged during early field exercises. On the basis of historical usage of similar items on the M60 tank, ARRCOM also increased projected failure rates and other factors. ARRCOM requirements determination documentation was often not compatible with documentation regarding quantities of parts placed on contract. Since we were unable to resolve differences, we could not effectively evaluate potential overbuys. However, based on the large quantities of additional stockage for about 200 high value items and the other factors previously discussed, we believe excessive quantities of spare and repair parts may have been procured. However, since failure factors were estimated and were not demonstrated in testing, the additional parts might be required.

By not fully using the standard methodology, the Army has ordered spare and repair parts that appear to exceed provisioning requirements for the first 3 years of production. These purchases and the methods used to generate such purchases should be reviewed before additional parts are ordered.

SPARE AND REPAIR PARTS MAY BE OBSOLETE BEFORE NEEDED

As a result of slippages in the tank production and deployment schedule, the Army may need to revise current spares delivery schedules to preclude the stockage of parts which may be obsolete before they are needed. The M1 tank configuration has been continuously modified since spare and repair parts requirements, valued at over $428 million, were identified to

support the first 3 years of tank production. The Army has accepted delivery of parts to support various training and testing activities, and the New Cumberland Depot is accepting parts to support initial fielding activities in Europe. However, many of these parts may be obsolete because of engineering design or production changes which have already been made or will be required to the tank and its major components.

According to contractual agreements between the Army and Chrysler, the spare parts delivered should be of the same configuration as the components used for tank production. But, Army officials said that, without having access to a production tank and an accurate technical data package, they are uncertain whether the spare and repair parts are the same as the components on production tanks. Other officials stated that quality assurance problems demonstrated during ongoing testing raise considerable doubt about the quality of the spare and repair parts. Furthermore, because the tank configuration continues to be modified to correct design deficiencies, future changes may result in the need to modify the types and quantities of spare and repair parts procured.

The compatibility of M1 spare and repair parts with tank production configuration should be verified, and inconsistencies should be resolved through retrofit or new procurement. Additional action should be initiated to minimize future incompatibilities. The Army should consider delaying acceptance of some spares previously ordered until an up-to-date technical data package of the production configuration is delivered and until a realistic production and fielding milestone schedule is determined.

With regard to our concern that excessive provisioning in the first few years may result in obsolete parts, DOD officials stated that provisioning of obsolete parts is an obvious concern; however, a modest initial overprovisioning should not of itself be condemned. It can be argued that overprovisioning initially reduces subsequent requirements and may be a wash economically or, in some instances, a net savings to the Government.

ADOPTING ALTERNATIVE PROCUREMENT STRATEGIES COULD DECREASE COSTS OF M1 SPARE AND REPAIR PARTS

Procurement costs for spare and repair parts could be decreased by adopting alternative procurement strategies, including (1) phased provisioning, (2) breaking away from sole-source procurement of spares from Chrysler, (3) integrating acquisition of spares with acquisition of production components, and (4) initiating second sources to promote future competitive procurements.

Problems with current M1 spares procurement

Spare and repair parts, valued at over $428 million, are being procured to support M1 training and testing activities and the

first 3 years of fielding. The contracting procedures used by two major Army readiness commands do not precisely identify all needed parts, quantities to be procured, or the price to be paid for each item. Army officials said that, due to the immaturity of the tank and its components, firm prices have not been negotiated and current sole-source contractual agreements with Chrysler have not been definitized. Instead, part orders are written based on the commands' contractual agreements, which contain a monetary limitation that will later be converted to ceiling prices as parts definitions and quantities are stabilized. 1/

According to Army officials, the commands could not avoid using these procurement strategies because

--tank design has not stabilized, and the prime contractor retains control over tank component configuration;

--tank production schedules, proposed maintenance strategies, fielding plans, and other factors which affect spare and repair parts requirements have fluctuated drastically and have not yet been finalized; and

--technical documentation is incomplete and of questionable accuracy.

Although alternative procurement strategies for acquiring M1 spares may be limited because of the immaturity of certain systems and the inaccuracy and incompleteness of available technical documentation, opportunities exist for decreasing future spare costs through the alternatives discussed below.

Phased provisioning

The Army should consider using phased provisioning before it procures M1 components to support anticipated fourth and fifth year tank production. Phased provisioning provides for deferring the procurement of all or part of the total computed requirement for a given component, pending stabilization of design and development of firm operational and maintenance plans and deployment programs. Such deferral enhances the ability of the provisioning activity to predict requirements more reliably.

Procurement orders placed with the contractor for initial support items (spare and repair parts) exclude those items selected for phased provisioning, or are limited to minimal quantities. Instead, arrangements are made for the contractor to accelerate the manufacture of these items so as to create a production buffer stock. The buffer stock, although managed by

1/TACOM negotiated similar sole-source contractual agreements valued at $43 million with two major subcontractors.

the contractor as inproduction materiel, acts to offset the range and quantities of selected items not procured. The items in the buffer stock are available upon order for delivery with significant reductions in lead times. Thus, the buffer stock serves as an interim source of responsive supply to meet demands of the using military services.

Detailed selection criteria and policy guidance for implementing a phased provisioning program are specified in Military Standard 1517 and in various DOD directives and Army regulations. Although phased provisioning has not been implemented for the M1 program, opportunities still exist for further consideration of the merits of this concept before additional spare and repair parts are procured.

Breakaway of spares procurement from prime contractor

Another alternative procurement strategy, which the Army could use with little or no risk, would be to negotiate directly with major subcontractors for the acquisition of major spares.

Army officials said that the costs of spares procured from Chrysler have not yet been definitized, but they may greatly exceed the cost of the same components on production vehicles. One reason stated for this disparity is the Chrysler fee (estimated at between 8 and 15 percent of spares acquisition costs) for managing spares procurement with the major subcontractors.

TACOM has already begun to procure spares directly from two major subcontractors. According to TACOM officials, this effort has been successful and will be expanded in the future. ARRCOM officials stated that the immaturity of turret systems and the incomplete and inaccurate technical data package have precluded past procurement of spares from the major turret systems subcontractors, but action is underway to establish contractual arrangements with major subcontractors to provide a vehicle for accomplishing future breakaway of spares procurement.

Spares acquisition integrated with production

Spares acquisition integrated with production is a procedure used to combine ordering and production of spares with identical items produced for installation on the primary system to be delivered to the user. To use this procedure, which was developed by the Air Force, contractors and subcontractors must combine orders for initial spares with installation requirements. In this way, the costs associated with separate material orders and manufacturing actions for spares and installation parts can be avoided. Additionally, the procedure provides for design consistency of spares and items for production installation by directly linking configuration control activities.

In many cases, Chrysler managed the acquisition of M1 spares separately from the acquisition of production components. According to Army officials, the original objective was to manage these acquisitions together, and this objective was a primary reason why the Army had to determine spares requirements so early in the acquisition cycle.

Establishing second sources

There are three primary reasons for establishing second sources from which to procure major M1 systems (such as the engine and fire control). The reasons are to gain savings through later competition, to increase the availability of hardware, and to broaden the active mobilization base and thereby ensure operational readiness by reducing the risks inherent in a single source.

Army officials told us that two primary methods exist to establish a second source. The first method is to split the current production quantity between the current producer and a new producer. This method has many risks, especially the unavailability of current production items in the event of nondelivery by the new source. Army officials stated that this method caused serious production delays in the Army's M60A3 tank program. 1/ The second method, referred to as an educational buy, provides for pulling forward an out-year requirement to avoid a current shortfall should the second source encounter production difficulties.

The educational buy program has been recommended by ARRCOM for the acquisition of six major turret systems. The proposed program is designed to ensure that adequate leadtime is allowed for product maturity, testing, and learning curve development, without threatening current production requirements. To accomplish these objectives, the components contracted for in the initial phase of the M1 program would be in excess of currently projected, and funded, requirements. Thus, program funding would have to be increased in the initial phases. Because quantities scheduled for out-year procurement would be decreased, this initial increase would be offset.

The Army has approved, but has not funded, the educational buy program. ARRCOM officials told us that its potential benefits decrease each year that the program is delayed.

1/Our June 30, 1980, report, "Late Fire Control System Deliveries for Army's M60A3 Tanks Jeopardize Combat Readiness Improvements" (LCD-80-79), discussed how delayed delivery of fire control systems resulted in producing hundreds of incomplete tanks, incurring additional costs, and reducing combat readiness.

CONCLUSIONS

Deficiencies in early M1 ILS planning caused roadblocks which precluded an effective and efficient provisioning effort. When initial provisioning requirements were to have been identified, insufficient data was available to fully use the Army's standard provisioning system. Army activities initiated extraordinary efforts to identify parts requirements using other methods. But, without having accurate information on the tank configuration, maintenance and fielding plans, production schedules, or technical documentation, Army activities could not effectively determine provisioning requirements.

M1 technical documentation should be updated to the most current tank configuration and should be appropriately adjusted when production vehicles have multiple configurations of the same component. Spare and repair parts requirements should be reconsidered based on current production and fielding schedules, maintenance allocations, and other factors. Revisions should be made as appropriate to parts on contract as well as to previous projections for future requirements.

A configuration audit should be made to validate spare and repair parts delivered to the New Cumberland Depot to ensure their compatibility with tank components and technical documentation. A sample of these spares should also be tested to confirm that quality assurance requirements have been met.

To provide for the most cost-effective use of future spare and repair parts, the Army should also initiate alternative procurement strategies, based on the appropriateness of each strategy for the level of maturity of the tank and the technical data package.

RECOMMENDATIONS

We recommend that the Secretary of Defense require the Secretary of the Army to:

--Update M1 technical documentation to the most recent production tank configuration, making appropriate adjustments in documentation to reflect configuration deviations, and direct that changes to technical documentation, reflecting future tank modifications, are processed promptly.

--Reevaluate M1 requirements for spare and repair parts and proposed delivery schedules based on a realistic assessment of current program data. The reevaluation should determine that sufficient, but not excessive, parts are provisioned in view of such factors as design maturity, the maintenance plan, failure rates of parts, and tank production schedules.

--Make a configuration audit to identify incompatibilities between spares and tank production components and ensure

that overhaul, retrofit, or other appropriate actions are taken, as needed, to provide conformance.

--Implement alternative procurement strategies, including phased provisioning, to ensure that future spare and repair parts are procured using the most cost-effective methods, consistent with the level of maturity of the tank and required technical data.

AGENCY COMMENTS

DOD agreed to review alternative procurement strategies, such as phased provisioning, and to implement such strategies where readiness and cost effectiveness can be enhanced. DOD did not comment on our other recommendations.

CHAPTER 8

M1 TANK TRAINING COSTS

MAY BE TOO HIGH

The Army is planning to spend approximately $1,137 million for tanks and training devices to be used for initial and proficiency training of M1 tank crews. This amount could be substantially reduced if requirements for tanks and training devices were better defined and if tanks and equipment needed for training were used more efficiently.

NUMBER OF M1 TANKS NEEDED FOR TRAINING MAY BE OVERSTATED

The Army's projection of M1 tanks needed for training is based on questionable methodology and, therefore, may be overstated. The Army plans to purchase 348 1/ M1 tanks, costing approximately $887 million, for training M1 tank crews and maintenance and support personnel. According to TRADOC officials, this requirement was determined using the same methodology as that used to compute training requirements for the M60 tank program.

M60 training tanks appear underused

The Army has authorized 389 2/ M60 tanks for training at Fort Knox, the Army's primary tank training center. We were unable to identify established criteria on how much usage these tanks should receive. Furthermore, records for evaluating past usage of training vehicles were not comprehensive. But our analysis of Fort Knox's operational data showed that, of 361 tanks on hand, only 245 were used for training during a recent 6-month period. Also, 129 of the tanks were used less than 5 hours a week, and 152 tanks traveled less than 15 miles a week.

1/During our audit, documentation showed that M1 training tank requirements were 419--397 at Fort Knox, Kentucky; 3 at Vilseck, Germany; and 19 at Aberdeen Proving Ground, Maryland. However, in responding to our draft report, DOD officials stated that revised estimates for training tanks call for the following: Fort Knox, 308; Vilseck, 21; and Aberdeen Proving Ground, 19--for a total of 348 tanks. Also, in responding to congressional committee questions (based on a draft of this report), the Army stated that 348 tanks are needed to support not just the currently authorized 7,058-M1 tank fleet, but a full main battle tank fleet of M1s.

2/This quantity does not include the 194th Armored Brigade, although this activity is periodically tasked to support training activities for the U.S. Army Armor School.

Fort Knox officials said that this data did not accurately assess total utilization because this data included only the time that tanks were operational (that is, the engine was running). Many tank training requirements, such as maintenance training and introductory crew exercises, do not require the tank to be operational.

To evaluate both operational and nonoperational M60 tank requirements, we reviewed Fort Knox training schedules which listed the most recent overall tank training requirements from February to September 1980. We found that the maximum number of tanks needed on any single day was 209 and that fewer than 176 tanks were needed 89 percent of the time.

Recognizing that tanks are not always available for training due to scheduled or unscheduled maintenance, we calculated the number of tanks needed to ensure that the maximum number of tanks are available on any single day. Fort Knox officials stated that the average availability rate for their tanks was approximately 88 percent. Using a conservative availability rate of 80 percent, we determined that 261 tanks are needed to ensure that 209 tanks are available on any given day. This figure is substantially below the number of tanks authorized for training at Fort Knox.

<u>Use of training devices not considered when computing tank requirements</u>

Current Army training plans include spending over $250 million to acquire training devices, including projected development costs. However, the requirement for tanks to support M1 training was determined without considering the substitution of training devices for tanks in various training programs.

Training devices can be used instead of actual weapon systems to provide realistic training. These devices can substantially decrease costs by reducing the requirements for tank hardware, replacement parts, fuel, and ammunition. Training devices also provide a flexibility to simulate environmental and operational situations which may be impracticable using actual production tanks.

The Army armor community has traditionally preferred training programs which rely almost exclusively on actual production hardware. The M60 training program uses few training devices; consequently, training requirements for operational crews, maintenance personnel, and weapons fire control have been met using production tanks.

In the last few years, due to various operational, environmental, and economic considerations, the Army has reassessed armor training strategies and the potential role of training devices. In support of M1 training requirements, the Army has committed over $40 million to develop three types of training devices. (See photograph on p. 73.) The development of M1 training devices

has lagged behind the tank development schedule, and M1 training devices will not be available to support initial M1 training as required by Army regulation. TRADOC officials told us that until prototype models are successfully tested, the Army is not committed to acquiring production models. Therefore, training requirements for tanks were not reduced to accommodate the eventual substitution of training devices.

We believe that the Army should accelerate the training device program--to the extent possible without compromising the quality of the program. We also believe that the Army should finalize its plans for using training devices in the M1 training program. Incorporating M1 training devices into the overall training program could substantially reduce the requirement for training tanks, especially for those training requirements which do not require vehicles to be operational.

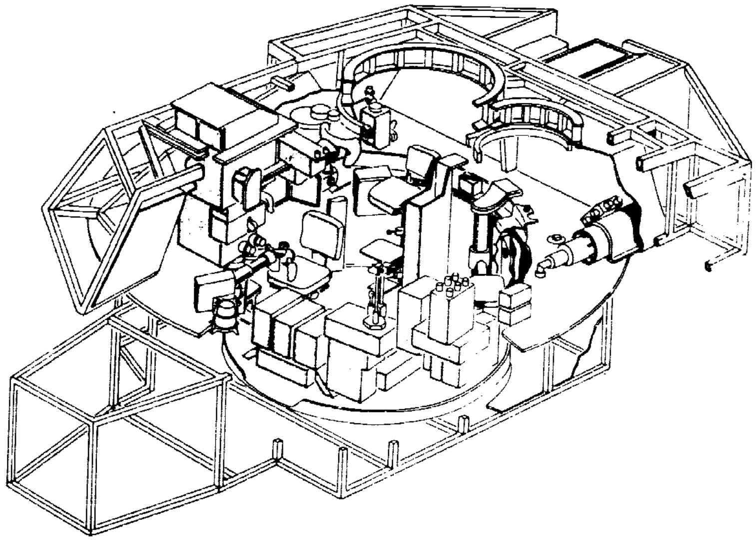
Responding to our concerns that excessive quantities of tanks were identified for training, TRADOC officials stated that "the GAO perception that Fort Knox has an excessive number of tanks must be reviewed against the benefits obtained through the strategies for training currently in use." These officials stated that requirements for tanks had been determined, more or less, independently for each major subordinate command within the U.S. Army Armor School. Tank requirements were not calculated for the installation as a whole, but were based on current operational experience.

Therefore, the U.S. Army Armor School is conducting a review which will (1) collect actual usage data for the tank fleet, (2) validate the current method used to determine tank requirements, and (3) assess the quality of the school's training efforts in terms of resources expended. Army officials stated that this review would focus on the cost-benefit relationships of various training modes.

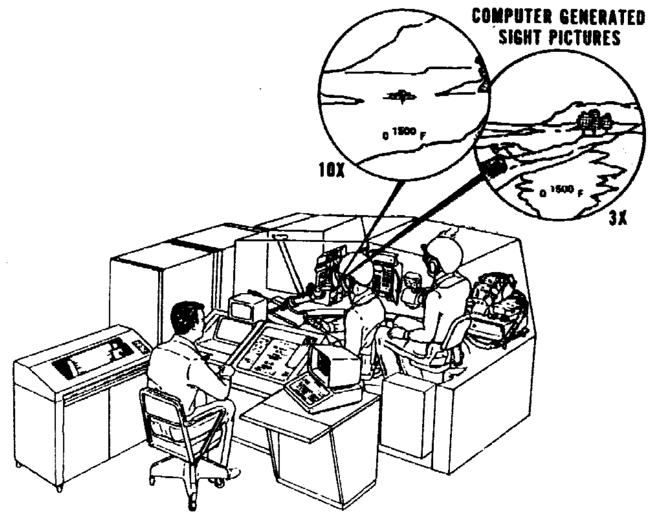
EFFECTIVE USE OF TRAINING DEVICES COULD REDUCE QUANTITIES REQUIRED

To support the M1 training program, the Army is developing three types of training devices. These devices are a conduct-of-fire trainer, a driver trainer, and a maintenance trainer.

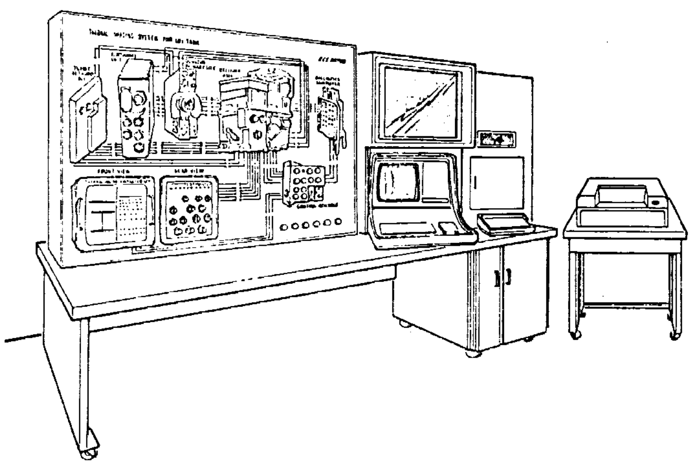
The conduct-of-fire trainer, a mockup of the tank crew compartment for the gunner and tank commander, is designed to simulate various gunnery modes and battlefield environments. The two types of conduct-of-fire trainers are the unit conduct-of-fire trainer (U-COFT) and the one-station unit-training conduct-of-fire trainer (OSUT-COFT). The former is used at the battalion unit level for both transition and sustainment training, and the latter consists of five stations monitored by a single instructor station and is used for institutional training.



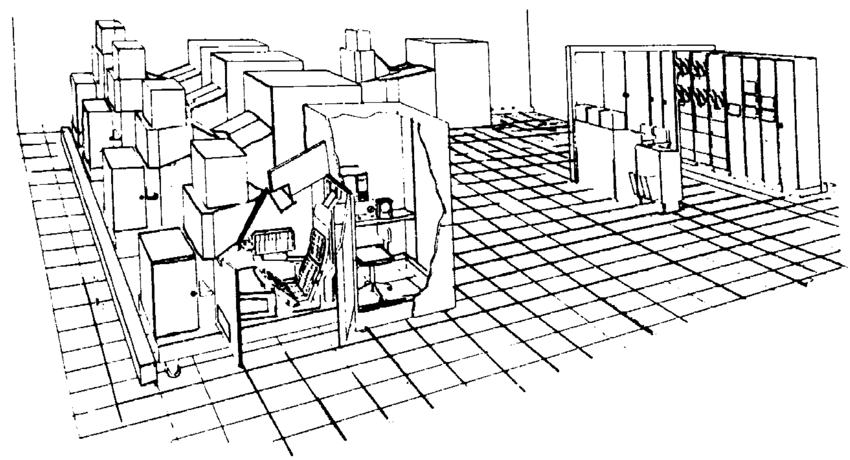
MI TURRET ORGANIZATIONAL MAINTENANCE TRAINER



UNIT–CONDUCT OF FIRE TRAINER



MI PROGRAMMABLE TRAINER (TROUBLE SHOOTING)



MI DRIVER TRAINER

The driver trainer is used for institutional training and consists of five trainee stations and an instructor station. Each station is a mockup of the tank driver's compartment. The maintenance trainer is a set of trainers consisting of the hands-on mockup of the tank turret and six programmable panels for training the organizational, direct, and general support maintenance level mechanics on troubleshooting procedures.

The cost of the trainers and the Army's planned purchases are shown below.

Type of trainer	No. to be bought	Average production cost per unit
		(millions)
OSUT-COFT	4	$10.1
U-COFT	78	1.7
Driver trainer	7	4.1
Maintenance trainer:		
Turret mockup	18	0.3
Programmable panels	65	0.1

By more effectively using training devices, the Army could reduce the total number of devices needed for M1 training. After the Army selects its devices, it should consider the potential savings from

--using devices more than the scheduled 40 hours a week and

--centralizing training where practicable.

Potential to increase the time training devices are used

The design specifications for M1 training devices require that they have a 90-percent operational availability based on an 80-hour workweek. However, the planned usage for most of the devices is only a 5-day, 40-hour workweek. Army officials stated they were not planning to use the devices to their designed capability primarily because morale would be affected by training in shifts and/or by using the devices more than 5 days a week.

Given today's problem of low soldier retention rates and the need to emphasize quality of life, consideration of training schedules which vary from the normal single-shift, 5-day routine must certainly include an evaluation of troop morale. Additional instructor costs might also be incurred for additional shifts of training. However, given the high cost of these devices, all

training alternatives should be carefully evaluated so that training device costs can be minimized. Without compromising the Army's intended objective of improved training and reduced diversion of combat tanks for training exercises, more careful evaluation of training device requirements may suggest options which should be considered. For example, if requirements for a U-COFT at a given location are 40 to 60 hours a week, optional training schedules may be preferable to investing in a second trainer at a projected cost of almost $2 million.

Geographic trainer consolidation

Current Army distribution planning provides that training devices will be placed at various Army bases in the United States, Germany, and Korea, as well as in the following Army schools: U.S. 7th Army Training Center, Vilseck, Germany; U.S. Army Armor School, Fort Knox, Kentucky; and U.S. Army Ordnance Center and School, Aberdeen Proving Ground, Maryland.

It appears that the potential exists to further reduce training costs by consolidating the U-COFTs planned for Germany. Although we did not make a cost-benefit analysis to determine the practicability of consolidated training, we noted that bases in Germany are in close proximity. For example, of the 27 European activities where U-COFTs are to be located, 15 are within 20 miles of another activity. Consolidating the training device requirements among these activities could reduce the currently projected 18 U-COFTs to 14. Requirements could be further reduced if a 40-mile radius were used; six U-COFTs could be eliminated. Because of the potential savings available, the Army should evaluate the feasibility of consolidating the placement of U-COFTs.

CONCLUSIONS

The Army based its M1 training tank requirements on the methodology used to compute M60 tank training requirements. This methodology may overstate training requirements because many M60 training tanks are underused. In addition, the methodology did not compensate for the fact that training devices, instead of tanks, could be used to provide training. The Army currently plans to spend over $250 million to acquire training devices to support the M1 program. Therefore, the methodology used to calculate the number of M1 tanks needed for training should recognize that using training devices could reduce the number of tanks needed. Army officials stated that until the effectiveness of M1 training devices is determined, no adjustment can be made to the number of tanks required to support the training base.

The Army could also reduce training costs through increased use of training devices. Training devices for the M1 program require a 90-percent operational availability based on an 80-hour workweek. However, the planned usage for most of the devices is for only a 5-day, 40-hour workweek. If trainers were used in the evenings or on the weekends, morale problems could surface

and instructor costs could increase; however, such alternatives should still be explored if the other option is to buy a greater number of expensive trainers. There may also be opportunities to consolidate trainers at bases in close proximity. This is primarily true for the U-COFTs in Europe where plans are for each base to have one trainer, and 15 of the 27 bases are within 20 miles of another base.

TRADOC officials told us that, in response to our findings, they would validate the current methodology used to determine training tank requirements and focus on the cost-benefit relationship of various training modes.

RECOMMENDATIONS

We recommend that the Secretary of Defense direct the Secretary of the Army to:

--Reevaluate the number of training tanks used in the M60 program and projected for the M1 program and to reallocate unneeded M60 tanks and reduce the projected purchase of M1s or reallocate them to operational needs.

--Determine if M1 training devices can be used more effectively by, for example, using them more than 40 hours a week and/or consolidating them in nearby areas.

AGENCY COMMENTS AND OUR EVALUATION

DOD concurs with our recommendation to reevaluate the number of training tanks used in the M60 program and projected for the M1 program and to reallocate M60 tanks and reduce the projected purchase of M1s or reallocate them to operational needs. In fact, in response to our concern during the audit, the Army is already proceeding with such a reevaluation.

However, according to DOD's response, there are a number of unknowns which will preclude establishing a final, definite number of M1 tanks for the training base for some time. Also, DOD said there are other factors which the Army will consider in making a final determination of the requirement for tanks for training.

Regarding our recommendation to identify more cost-effective methods of utilization for M1 training devices, DOD concurred in principle. For example, DOD said it is not adverse to using training devices more than 40 hours per week if it proves to be cost effective. DOD also said that funding an extra shift of qualified instructors is a more important factor than the morale of troops required to work outside normal duty hours as we had been told by training officials. DOD said it will reevaluate training requirements after training devices complete developmental testing.

Concerning our recommendation for consolidation of conduct of fire trainers, DOD stated that our cost effectiveness analysis failed to consider the value of increased readiness of tank units through intensified use of U-COFTs. About half of all tank units in the Army are stationed in Germany. These units are expected to be the most combat ready in the Army, but because of the shortage of range space, gunnery practice per unit is minimal. The U-COFT will be used to maintain the proficiency level of the tank commander-gunner team and allow for more productive use of range time.

DOD also believed that if the U-COFT is as effective a training device as it is expected to be, the available evidence suggests that one per base is less than optimal. However, DOD did agree that the Army would reevaluate the requirement for these trainers.

While we agree that the primary value of U-COFT is increased tank readiness, this factor in itself does not preclude geographical consolidation. We still believe the Army's evaluation should include U-COFT consolidations.

OTHER M1 SUPPORTABILITY ISSUES

In addition to the M1 supportability issues addressed in detail in this report, we are concerned about the availability of resupply vehicles, sufficient numbers of properly trained troops to support the M1 when fielded, and adequately trained Reserve personnel to support the M1 Active Forces in the event of a mobilization.

VEHICLES TO RESUPPLY FUEL AND AMMUNITION

Due to shortages in fuel and ammunition resupply vehicles, the Army may not have sufficient quantities to achieve required readiness capability in the event of a war.

In fiscal year 1982, the Army requested funding to buy additional M1 support vehicles, and the required funding was partially approved. The Army plans to field the first M1 units in early fiscal year 1982. Army officials said these units will be fully supported by redistributing the vehicles currently used by M60 tank units. But, based on refueling and rearming studies and unit equipment authorizations, there is already a shortfall of support vehicles for M60 units. In addition, as M1s replace M60s, additional support vehicles will be required because the M1 uses 30 to 90 percent more fuel (preliminary testing indicates that the M1 requires 4 gallons a mile to operate) and carries eight 105-millimeter ammunition rounds less than the M60. Although redistribution may ensure that M1 and other high-priority units are combat supportable, the result will be a net reduction in the Army's overall readiness posture.

Army officials agreed that shortages in the Army's truck fleet would severely limit its ability to move petroleum and ammunition, as well as troops and other supplies in a war. They stated that procurement presently planned for tactical wheeled vehicles is insufficient to meet total Army needs. They stated that the Army has the most serious vehicle shortage since before World War II, but that this problem is not unique to the M1 and should not be attributed to increased M1 requirements. Although we recognize that this is not a unique problem, we believe the truck shortage will be aggravated by increased M1 requirements.

SUPPORT PERSONNEL AND SKILL REQUIREMENTS

Due largely to inadequate front-end logistics planning, development of M1 personnel and skill requirements was delayed. Furthermore, because of the continued occurrence of serious design deficiences and incomplete and inadequate logistics support capability during previous testing, the Army has been unable to validate the types, quantities, and skill levels of personnel which will be required to support the M1 in an operational environment.

The Army Military Personnel Center has identified eight skill specialities that are needed to operate and maintain the M1. These requirements were based largely on previous experience with the M60 tank, and their verification and an assessment of the total numbers of personnel required have been delayed pending the completion of ongoing operational tests. Until that time, there are a number of unanswered questions regarding the Army's capability to operate and maintain the M1. For example:

--How many maintenance staff-hours are needed to support the M1?

--Can M1 maintenance tasks assigned to the various maintenance levels be done by Army troops as currently trained and by using available manuals and test equipement?

--Are additional skill specialties needed to carry out maintenance tasks critical to M1 supportability, such as turbine engine repair and repair and calibration of automatic test equipment?

--Will the number of maintenance personnel at each maintenance level be sufficient to handle the M1 maintenance burden?

ARMY RESERVE SUPPORT

As much as 80 percent of the maintenance capability needed to support M1 mobilization at the direct and general support levels will come from Army Reserve components. However, the M1 comprehensive training plan does not address Reserve requirements. In addition, the Army has not identified those Reserve units which would be mobilized to support active M1 units nor has it developed and implemented a comprehensive training program to ensure that these Reserve personnel can adequately maintain the M1. These planning deficiencies will adversely affect the Army's M1 wartime mobilization capability.

M1 LOGISTICS REQUIREMENTS

Reliability

Mean Miles Between Failure

	System (note a)	Mission (note b)
Phase II testing	90	272
Phase III testing	101	320
Goal	107	360

Maintainability

Scheduled	Shall not exceed: Clock hours	Shall not exceed: Staff hours
Crew--daily checks	.75	3.0
Organizational--every 1,500 miles or semiannually	16	64

Unscheduled	90 percent of tasks shall not exceed: Clock hours	90 percent of tasks shall not exceed: Staff hours
Organizational	4	8
Direct support	12	48

Malfunctions - 90 percent detected and corrected at organizational level

Maintenance ratio - (Organizational level through direct support)

	Maintenance man-hours per operating hours
Phase I testing	1.47
Phase II testing	1.25
Goal	1.00

Durability

Vehicle - 6,000 miles

Engine/transmission/final drive

Phase II testing	.50 probability of 4,000 miles without replacement or overhaul of major components
Goal	.50 probability of 6,000 miles without replacement or overhaul of major components

Track - 2,000 miles per set without 10 percent shoe assembly replacement (note c)

Track pads - 1,500 miles per set without 10 percent pad replacement

Road wheel/idler wheel - 3,000 miles without 20 percent replacement

Sprockets - 1,500 mile average per set, minimum 750 miles per set

105-mm. gun tube - 1,000 rounds

105-mm. gun breech - 4,000 rounds

a/System reliability measures all chargeable equipment failures, even though the failures may not preclude mission capability.

b/Mission reliability measures the ability of an item to perform its required functions for the duration of a specified mission profile.

c/The current M1 track design does not have a replaceable pad.

REVISED M1 PROGRAM MILESTONES

AS OF APRIL 1981

Previous date	Current date	Event	Explanation or purpose
	Feb. 17, 1981	Special Army System Acquisition Review Council	1. Recommend a management plan to support award of third-year production and fourth-year long-leadtime items procurement contracts. 2. Type classification production vehicle.
Sept. 1981	Apr. 1981	Award contracts for third-year production at 30 tanks/month and fourth-year long-leadtime items	
May 1981	May 1981	Operational test III completed	Complete currently scheduled operational test activities.
Jan. 1981 and Mar. 1981	May 15, 1981	Data cutoff for evaluation to allow deployment to Europe and release for full production	
	Aug. 1981	Complete assessment of RAM-D during developmental test III	Other developmental testing activities continue until completion.

Previous date	Current date	Event	Explanation or purpose
Mar. 1981	Sept. 1981	Army System Acquisition Review Council	1. Review available data and validate achievement of RAM-D requirements and fielding readiness. 2. Authorize deployment.
June 1981	Sept. 1981	Defense System Acquisition Review Council	DOD considers action to increase tank production to 60 per month.
	Sept. 1981	Exercise contract option for 209 additional M1s in third-year production	Begin production assembly at Detroit Tank Plant.
	Feb. 1982	Complete maintenance evaluation	
	March 1982	Begin production deliveries at Detroit Tank Plant	

THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D.C. 20301

RESEARCH AND ENGINEERING

April 27, 1981

Mr. Donald J. Horan
Director, Procurement, Logistics, and Readiness Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Horan:

This is in reply to your letter of 13 February 1981 to the Secretary of Defense requesting review and comment on GAO draft report "Logistics Planning for the XM1 Tank: Implications for Reduced Readiness and Increased Support Cost," OSD Case No. 5640, GAO Code 947399.

Preliminary comments on the draft report were provided informally to the GAO staff in a meeting with OSD and Army representatives on 10 March 1981 and in several subsequent meetings. In response to request of 18 March 1981 from the Chairman of the Investigations Subcommittee, House Armed Services Committee, the Army has supplied its detailed comments directly to the subcommittee, including a summary consistent with the memorandum to USDRE from the Assistant Secretary of the Army (RDA) of 2 April 1981 (Enclosure 1 of this letter). The Department of Defense concurs with these comments.

The Department of Defense concurs in the major recommendations contained in the Digest of the GAO report. Actions have already been taken or initiated in each of the areas mentioned as described in enclosure 2 of this letter.

DoD comments on Chapter 7 of the draft report entitled "Savings Possible in the Purchases of Spare and Repair Parts" and Chapter 8, entitled "Tank Training Costs May Be Too High" are contained in enclosures 3 and 4, respectively.

The draft report contains on page 16 the statement "We recommend that the Secretary of Defense advise the Congress on what action can be taken to correct XM1 integrated logistic systems support deficiencies and to prevent the occurrence of similar problems on future systems". This recommendation has already been addressed. We have described actions

GAO note: Page numbers in this appendix refer to pages in the draft report.

underway to improve logistic support planning for future systems in our recent response to GAO's report of January 29, 1981 on "Effectiveness of US Forces Can Be Improved Through Improved Weapon System Design" (PSAD 81-17). Actions planned or underway to correct specific M1 support deficiencies identified by GAO are described in the enclosures to this letter. Detailed comments on the GAO report, in the form of marked up drafts, have been provided to the GAO staff in the interest of improving accuracy of the final report. (See GAO note)

In summary most of the GAO recommendations point out real or potential problems the DoD has already identified. Numerous steps are being taken to resolve or minimize the impact of these problems. Adequate supportability testing information, as well as results of actions described herein, should be available as a sound basis for a full production and fielding decision at ASARC/DSARC IIIA (September 1981). In this decision process, appropriate weighting will be given to all elements of system's performance.

We appreciate the opportunity to comment on the draft report before its formal issuance.

Sincerely,

David P. Hudson for

James P. Wade, Jr.
(Acting)

Enclosures 4

1. ASA(RDA) memo, 2 Apr 81 w/o encls
2. Status of DoD Plans to Implement the Major GAO Recommendations
3. DoD Comments on Chapter 7 of GAO Report
4. DoD Comments on Chapter 8 of GAO Report

GAO note: On the basis of DOD's comment, we deleted the recommendation from the final report. DOD's comments and planned actions to our January 1981 report respond to the intent of our recommendation. In accordance with section 236 of the Legislative Reorganization Act of 1970, DOD is mandated to report its response to our recommendations to key congressional committees.

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
WASHINGTON, D.C. 20310

8 APR 1981

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE FOR RESEARCH AND ENGINEERING

SUBJECT: Draft Proposed GAO Report #947399, undated

The Army generally agrees with many of the major recommendations made by GAO which are in the process of being accomplished or evaluated for implementation. The status of Army plans to implement the major GAO recommendations is attached. The Army does not fully agree with the rationale GAO used to arrive at their recommendations. We disagree with GAO's use of unsubstantiated cost savings claimed in the report and the inference that the Army should minimize M1 production and delay deployment until the "entire" system is totally mature. Such an approach obviously fails to recognize the critical need to field an improved tank, and also stretches out the acquisition cycle which incurs a tremendous expense. The Army is committed to proceeding with M1 production build-up and deployment plans while recognizing the near-term potential for supportability problems. We anticipate some problems and are developing ways to minimize these problems until they are successfully resolved. Also attached are detailed comments on the GAO draft report. Highlighted are some of the more significant points:

a. The report minimizes many of the positive aspects of Army and M1 logistic support planning and implementation which would have put the GAO assessment in a more objective perspective. The M1 program is an early example of the competitive prototype acquisition strategy. GAO does not directly acknowledge where the Army has incorporated ambitious new approaches to increased supportability consistent with the constraints of such a strategy. The M1 is the first major armored ground system with advanced technology test sets. When engineering is completed, these test sets promise significant readiness pay-offs for the life of the M1. The M1 also represents the first major implementation of the Skill Performance Aids (SPA) format (for manuals) with armored systems. These also will significantly contribute to a fully supportable M1.

b. The report challenges the lack of effective M1 front-end logistics planning and resourcing, but fails to portray the whole story. While the report acknowledges that the M1 program emphasis, as supported by Congress, has been on achieving established design-to-cost objectives and fielding a tank within a seven-year development cycle, it does not give the total perspective on why the Army made an early decision not to fund both GM and Chrysler ILS packages during prototype development. This decision was made in view of limited resources and it avoided double funding for the same requirement. It was planned that low-rate initial production of the tank

SUBJECT: Draft Proposed GAO Report #947399, undated

would provide sufficient time for ILS and supportability to mature before large quantities of tanks were fielded. In addition, although supportability was among the lower design tradeoff priorities for the tank and therefore subject to greater affordability and schedule tradeoffs and constraints, it was by no means ignored. Emphasis on support was given in part through concerted Army RAM-D efforts during the development program.

c. Many of the standards used by GAO to judge status of M1 ILS planning and implementation were not developed and implemented until the late 1970's when the M1 program was in its final phase and contracts had been negotiated. These standards are intended as guidance in planning acquisition programs. Programs like the Abrams are then tailored to meet constraints. The strict OSD guidance provided in DoD 5000.39 and 5000.40 was not provided until after the M1 was approved by OSD for limited production and funded by Congress.

d. The report contends that there are actions that could be taken to "drastically reduce" M1 ownership costs by "hundreds of millions of dollars." The GAO cites increased ownership costs associated with alternators and wiring harnesses that have had few if any of the type problems GAO mentions during recent testing. GAO claims should be removed from the report if the savings associated with these items cannot be substantiated.

e. Most of the GAO comments point out lessons which we have already learned from the M1 experience. This experience is a part of the continuing process to improve the Army's approach to logistic supportability during the development of major weapon systems. The M1 Abrams tank has been the most tested combat vehicle in the Army's history, running over 115,000 test miles. It achieved the majority of all significant performance goals during its FSED phase and continues to receive high soldier acceptance. For the past 18 months, it has been tested and maintained in a soldier environment. The tank is supportable in the near-term considering the relatively low production rate and intensive management of logistics issues. Adequate supportability testing information should be available for the Army to base a sound fielding decision at ASARC IIIA (September 1981). In this decision process appropriate weighting will be given to all elements of system's performance.

Arthur Daoulas

2 Incl
as

Arthur Daoulas
Acting Assistant Secretary of the Army
(Research, Development and Acquisition)

STATUS OF DOD PLANS TO IMPLEMENT THE MAJOR GAO RECOMMENDATIONS

GAO Recommendation #1: (p. V and p. 42)

Establish additional criteria for evaluating ongoing tests that recognize operational as well as inherent tank hardware characteristics. DoD response: Agree.

The Army has already established two new logistic burden parameters. An ongoing Army Manpower and Logistics Analysis (MALA) was initiated in November 1979 to quantify and evaluate the impact of fielding the M1 with various levels of RAM-D. As part of this analysis, logistic burden parameters (Mean Miles Between Essential Maintenance Demands (MMBEMD) and Maintenance Manhours per mile (MMH/M)) were developed and are being measured in DT/OT III to evaluate the operational as well as inherent tank hardware characteristics. The evaluation of logistic burden will be used to support ASARC/DSARC IIIA decisions on full rate production and fielding of the M1.

GAO Recommendation #2: (p. Vi and p. 42)

Reevaluate current program plans for increasing production capability and monthly production of tanks, deployment, acquisition of spare parts, etc., considering the potential consequences of continuing the program as scheduled given reliability and logistics support capability. DoD Response: Agree in principle. The Army at a Special ASARC on 17 February 1981, reassessed the tank's maturity and supportability and based on its progress since DT/OT II, type classified Standard the M1 Abrams tank. Conclusions reached by the Army as a result of reevaluation of the current program plans were as follows:

(a) To date, the majority of the M1 Abrams tank development is reasonably complete. Planning is sufficiently mature to insure adequate support of the M1 fleet.

(b) Maturation of remaining items can be completed without undue risk to M1 readiness.

(c) The tank is supportable in the near-term considering the relatively low production rate and intensive management of logistics issues.

Based on this reevaluation, the Army is proceeding with current program plans for increasing production capability and monthly production of tanks, deployment, and acquisition of logistic support.

The full production and deployment decisions are scheduled in September 1981 based on ASARC/DSARC IIIA reviews, which will include an evaluation of tank maturity, logistic support status, and associated risks.

Enclosure #2

GAO Recommendation #3: (p. Vi and p. 42)

Quantify and evaluate the impact (in terms of increased operation and maintenance costs and reduced operational readiness) of producing and fielding the M1 with currently demonstrated levels of reliability, availability and maintainability. DoD Response: Agree. The Army Manpower and Logistic Analysis (MALA) along with other standard materiel acquisition documentation such as Logistic Force Structure Analysis (LFSA) and Cost and Training Effective Analysis (CTEA), are specifically designed to quantify and evaluate the impact (in terms of increased operation and maintenance costs and reduced operation readiness) of producing and fielding the M1 with required and currently demonstrated levels of reliability, availability and maintainability.

GAO Recommendation #4: (p. Vi and p. 53)

Provide increased emphasis and resources, if needed, for the development, acquisition, and evaluation of required logistic support capability (i.e., test equipment, technical manuals, maintenance capability). DoD Response: Agree. During the years since ASARC/DSARC III, the management priority, funding support, and personnel resources devoted to development of test equipment, technical manuals and improvements to the maintenance concept have all increased. These logistical support elements are being evaluated in OT III at Fort Hood and in the Maintenance Evaluation at Aberdeen Proving Ground. Correction of any remaining deficiencies in these important areas will continue to receive emphasis.

GAO Recommendation #5: (p. Vi)

Devote needed resources to identify and implement potential life-cycle cost reductions through reliability and maintainability improvement and other means. DoD response: Agree. The Army's M1 Reliability and Maintainability (R&M) Growth Program was initiated in 1979. The objective of the program is to provide increased reliability for selected critical components and improvement of designs that exhibit marginal RAM-D characteristics. Concurrent with the above effort is an Integrated Logistics Support (ILS) Maturity Program which will assure that the tank will be logistically supportable. The objective is to continue to improve the quality of manuals, the adequacy of special tools and test sets, and to reduce the spare parts required to support the tank. In addition, maintainability improvements will be identified to reduce the tank's logistic burden as a result of DT/OT III, subsequent testing, and the MALA. RDTE funds programmed by the Army for RAM-D growth to meet the Mission Need (MN) are approximately $20M (FY81), $10.0M (FY82), and $6.0M (FY83). For improvements in reliability, maintainability and ILS, the Army has included $5.4M RDTE in the FY82 budget, $14.6M (WCTVA) in the FY81 supplemental request, and $31.1M (WCTVA) in the FY82 budget amendment. To be successful in realizing the potential M1 life-cycle cost reductions suggested by GAO will require increased funds in the FY82 and FY83 budget to implement the R&M Growth Program for the M1 tank.

GAO Recommendation #6: (p. Vi)

Reevaluate the requirement for tanks and training devices to support M1 training activities. DoD response: Agree. The Armor Center is studying the utilization of its M1 and M60 assets to see if they can be reduced consistent with peacetime and wartime training requirements. The effectiveness of institutional training devices has not yet been determined. M1 training devices are undergoing DT testing this year. Also, training device requirements will be reevaluated based upon results of these test. When their effectiveness has been determined, an adjustment to the number of tanks required to support the training base will be forthcoming. If tanks can be released by use of devices, they can be used to equip additional units.

DoD Comments on Chapter 7, "Savings Possible in the Purchases of Spare and Repair Parts"

It is DoD's policy to utilize phased provisioning whenever the potential exists. It is believed, however, that the wording in the two paragraphs in the draft report under the heading "Phased provisioning" may not clearly explain what is meant by the term phased provisioning. In order to avoid a possible misinterpretation, it is recommended that the following wordage be added to the first paragraph under the heading "Phased provisioning": "Procurement orders placed with the contractor for initial support items (spares and repair parts) exclude those items selected for phased provisioning, or are limited to minimal quantities. In lieu of procuring the total range and computed quantities of these selected items, arrangements are made for the contractor to accelerate the manufacture of these items so as to create a production buffer stock. The buffer stock, although managed by the contractor as inproduction materiel, acts to offset the range and quantities of selected items not procured. The items in the buffer stock are available upon order for delivery with significant reductions in lead times. Thus, the buffer stock serves an an interim source of responsive supply to meet demands on the supply systems of the using military services."

The Army will consider the merits of phased provisioning in the XM-1 program.

GAO Recommendation, page 80: "--Take action to implement alternative procurement strategies to assure that future spare and repair parts are procured using the most cost-effective methods, consistent with the level of maturity of the tank and required technical data."

DoD Comment:

Alternative strategies will be reviewed, and where readiness and cost effectiveness can be enhanced they will be used.

Enclosure #3

DoD Comments on Chapter 8, "XM1 Tank
Training Cost May Be Too High"

GAO Recommendation: "We recommend the Secretary of Defense direct the Army to reevaluate the number of training tanks used in the M60 program and projected for the XM1 program, and reallocate unneeded M60 tanks and reduce or reallocate to operational needs the projected purchase of XM1's."

DoD Response: DoD concurs with the recommendation; in fact, the Army is proceeding with such a reevaluation. However, there are at least two unknowns that will preclude establishing a final, definite number of M1 tanks for the training base for some time:

-The training plan is yet to be tested.

-The capability of the family of training devices to substitute for training tanks will not be known until the devices become available in sufficient numbers to be properly evaluated.

Even when these factors become better understood, there will remain several cogent reasons why the allocation of training tanks should not be excessively restrictive:

-The availability rate of M1's assigned to the training base is difficult to predict with precision until the tanks are subjected to some use (and abuse by trainees) in the training base environment.

-Some allowance must be made to accommodate such variables as fluctuations in availability rates, seasonal fluctuations in numbers of trainees, and capacity to absorb increased numbers of trainees during mobilization.

The Army will consider these factors in making a final determination of the requirement for tanks for the training base.

GAO Recommendation: "We recommend the Secretary of Defense direct the Army to determine if more effective use can be made of XM1 training devices, for example, using them more than 40 hours per week and/or consolidating them in areas of close proximity."

Enclosure #4

DoD Response: DoD concurs in principle, although it does not agree fully with some of the rationale GAO uses to arrive at the recommendation. For example, DoD is not averse to using training devices more than 40 hours per week in the training base if it proves cost effective to do so. Funding an extra shift of qualified instructors, however, is a more compelling factor in a cost-effectiveness analysis than the morale of the trainees required to work outside normal duty hours, the main drawback discussed by GAO.

A more serious omission in GAO's cost-effectiveness formulation, however, is its failure to consider the value of the increased readiness of tank units that will be available through intensive use of unit conduct-of-fire trainers (U-COFT's). These trainers will provide gunnery training that otherwise could not be provided at all. This factor is particularly important in establishing a basis for distribution of U-COFT's in Europe. About half of all tank units in the Army are stationed in Germany. These units are expected to be the most combat-ready tank units in the Army, but the availability of range space in Germany is extremely limited. Typically, a tank unit can expect to have only one extended gunnery practice and crew qualification opportunity per year, with perhaps one other short practice/sustainment session. During the course of the intervening year either the tank commander or gunner of the typical tank crew will change due to rotation, promotion, etc. Consequently, much of the available range time, even for experienced crews, must be spent in getting up to speed and establishing crew coordination. The major potential value of U-COFT is in maintaining the proficiency level of the tank commander-gunner team. This allows a more productive use of available range time and, even more important, provides a means to maintain a higher year-round level of crew readiness than is presently available. The Army will take these factors into account when it is firming up its acquisition and distribution plan for U-COFT.

Two other factors argue for a liberal distribution of U-COFT's:

-Tank unit commanders in Europe must build their training schedules around periodic training sessions at Major Training Areas for maneuver as well as gunnery training. This time is so scarce and precious that it must be taken whenever available even if it interrupts an orderly progression of training. Introducing an additional element of inflexibility by requiring extensive sharing of U-COFT's would make it doubly difficult to plan and conduct a rational training schedule.

-The updated unit cost of a single U-COFT, $2.09 million, is roughly the same as the cost of an XM1 tank. If a U-COFT can raise the proficiency of each of the 54 tank crews in a battalion by only 5 percent (certainly a very modest objective) it can amortize the U-COFT's cost very rapidly. Any further savings through decreased wear and tear, lower fuel and ammunition costs, etc., that might accrue would be a bonus.

In summary, if U-COFT is as effective a training device as it is expected to be, it can pay for itself through enhanced readiness alone. The available evidence suggests that a distribution of one U-COFT per tank battalion would be reasonable and cost effective, especially in Europe (even so, the Army presently plans to limit the distribution of U-COFT's to less than one per battalion). The distribution of U-COFT's is not a place to strain for marginal economies gained at the expense of a significant improvement in readiness. The GAO report should reflect this perspective.

GAO Recommendation: "We recommend the Secretary of Defense direct the Army to reevaluate the requirement for conduct of fire trainers and consider substituting U-COFT's for the more expensive OSUT-COFT." (See GAO note)

DoD Comments: DoD concurs with the first part of the recommendation. The reevaluation will include the factors discussed under the previous recommendation.

DoD believes the second part of the recommendation, and the supporting text, should be withdrawn. Under the most recent cost projections, a grouping of five U-COFT's would cost $10.5 million (plus the expense of three more instructors); the unit cost of an OSUT-COFT (now called I-COFT) is projected to be somewhat less, $9.9 million.

GAO note: On the basis of the updated cost information provided by DOD, we have deleted the second part of the recommendation that the Army consider substituting U-COFTs for the more expensive OSUT-COFTs. We recognize this would not be cost effective.

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